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DEPARTMENT OF THE INTERIOR

BULLETIN

OF THE

UNITED STATES

GEOLOGICAL SURVEY

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1900

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UNITED STATES GEOLOGICAL SURVEY

CHARLES D. WALCOTT, DIRECTOR

SURVEY

OF THE

NORTHWESTERN BOUNDARY OF THE UNITED STATES

1857-1861

BY

MARCUS BAKER

WASHINGTON

GOVERNMENT PRINTING OFFICE

1900

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LETTER OF TRANSMITTAL.

DEPARTMENT OF THE INTERIOR,
UNITED STATES GEOLOGICAL SURVEY,
Washington, D. C., June 9, 1900.

SIR: I have the honor to transmit herewith, for publication as a bulletin, an account of the establishment of and survey of the boundary line between the United States and Canada, along the forty-ninth parallel, from the summit of the Rocky Mountains to the Pacific.

Very respectfully,

MARCUS BAKER, *Cartographer.*

Hon. CHARLES D. WALCOTT,
Director United States Geological Survey.

SURVEY OF THE NORTHWESTERN BOUNDARY OF THE UNITED STATES, 1857–1861.

By MARCUS BAKER.

INTRODUCTION.

By the Northwestern Boundary, as here used, is meant that part of the boundary line between the United States and Canada which extends from the summit of the Rocky Mountains westward along the forty-ninth parallel to the seacoast at Point Roberts and thence through the waters of Georgia, Haro, and Juan de Fuca straits to the Pacific. This line naturally divides itself into two parts, the land boundary and the water boundary. This paper treats only of the land boundary. As to the water boundary, the joint commission charged with the survey disagreed, and its location was finally determined by arbitration in 1871, the arbiter, Emperor William I, of Germany, deciding in favor of the American claim. The prominence given this part of the line, growing out of the arbitration, has made its history well known. In regard to it there is an abundance of printed material. The history of the land boundary, however, is very imperfectly known. Little has been published respecting it, and its story is to be gathered largely from manuscript memoranda, notes, sketches, pictures, correspondence, and the memories of men still living.

From time to time information respecting this line is needed by the Executive Departments. In 1897 the Geological Survey was directed by Congress to survey and mark the boundary between Montana and Idaho. In performing this duty it became necessary to connect with the survey of the forty-ninth parallel. The search then made of the records in the State Department showed the desirability of preparing a concise history of the northwestern boundary, its establishment, survey, and marking, with a summary of results. To exhibit such a history and summary is the object of this bulletin.

SOURCES OF INFORMATION.

The sources of information from which this account is prepared are three, viz:

(a) Government publications, consisting of the Statutes at Large, executive documents, official reports, etc.

(b) Manuscript records in the State Department, consisting of the original notebooks, observations, computations, plattings, sketches, maps, correspondence, etc.

(c) The memories of some of the surviving participants in the survey. These will be discussed in the order indicated above.

(a) In the Statutes at Large are contained all laws enacted by Congress touching the boundary, including also all the treaties. For the original treaty of June 15, 1846, see vol. 9, pages 869–870; for the act creating the commission to survey and mark the boundary, vol. 11, page 42; for various appropriation acts, vol. 11, pages 42, 159, 312, 403; and vol. 12, page 20.

On November 12, 1859, Lieut. (now Gen.) John G. Parke, chief astronomer and surveyor, made a short report of progress. This is a document of 7 pages and is printed as Senate Ex. Doc. No. 16, Thirty-sixth Congress, first session. It is here reprinted as Appendix B.

Nothing further, in official documents, appears for nine years. The civil war turned attention to more urgent matters and this subject was dropped. In February, 1868, however, President Johnson sent to the Senate a long communication on the San Juan boundary question. This document (Senate Ex. Doc. No. 29, Fortieth Congress, second session) of 280 pages, though dealing chiefly with the water boundary, nevertheless throws considerable light on the history of the land boundary.

On January 13, 1869, the House of Representatives, by a resolution, requested information as to expenditures by the Northwestern Boundary Commission. In response, a message from President Johnson was laid before the House of Representatives on February 13, 1869. (House Ex. Doc. No. 86, Fortieth Congress, third session.) This document of 102 pages is almost wholly given to a detailed tabular exhibit of expenditures. There is, however, a letter of 4 pages from the commissioner, Hon. Archibald Campbell, summarizing the entire history of the survey. This is apparently the nearest approach to a report on this subject that has ever appeared in print.

Finally, in 1889, Capt. George M. Wheeler, U. S. A., published in his report upon geographical surveys west of the one hundredth meridian (vol. 1, pp. 614–619) a short account of the Survey of the Northwestern Boundary of the United States 1857–1861.

(b) The manuscript records of the survey are nearly all contained in two blue chests stored in the division of manuscripts in the library of the State Department. Some of the maps being too large to go into these chests are kept elsewhere in the library. The memoranda, notes, correspondence, maps, etc., in this collection are the chief source of information from which this account has been prepared. But unfortunately the most important document of all was not found there, and a diligent search has failed to bring it to light. This paper is the fin*report, written on foolscap* paper and consisting of four parts, one l

Archibald Campbell, the commissioner; one by Gen. J. G. Parke, chief astronomer and surveyor; one by G. Clinton Gardner, assistant astronomer and surveyor, and one by J. S. Harris, general assistant. For this description of the missing manuscript I am indebted to Mr. William J. Warren, Bureau of Engineers, War Department. When Captain Wheeler was preparing his account of this survey he made an unsuccessful search for this missing report. He says:[1]

I have been unable to trace the manuscript of the final report, including that of the chief astronomer and the specialists, which it is believed was made. According to the Journal of the Senate of February 9, 1871, this report was called for by the Senate, but a search of the Senate records and also those of the State Department, made at my request by Mr. Dwight, librarian of the State Department, remained unavailing on June 15, 1887. Mr. William J. Warren, secretary of the commissioner [and] now chief clerk [in the office] of the [Chief of] Engineer[s] [War] Department, recollects to have seen the manuscript of this report at the office of the Northern Boundary [Survey], established in 1873, as does also Maj. J. F. Gregory, Corps of Engineers, a member of that commission, but it could not be found by Mr. Dwight in the records transmitted at the close of the latter survey to the State Department.

The search above mentioned I have now repeated and with like result. The manuscript has not been found.

The existence of the manuscript is attested by Mr. Warren, who gave me the description above written. The call for it made by the Senate in 1871 is set forth in the following extract from the Senate Journal of February 9, 1871, page 254:

Mr. Howard [Jacob M., of Michigan] submitted the following resolution, which was considered by unanimous consent, and agreed to:

"*Resolved*, That the President be respectfully requested, if not incompatible with the public interests, to transmit to the Senate copies of the final report, and the accompanying documents, of the commissioner on the part of the United States to carry into effect the first article of the treaty with Great Britain of June 15, 1846."

An examination of the records in the office of the Secretary of the Senate reveals no other entry concerning it, from which it is concluded that it was never sent. Similarly an examination of the records in the Index Bureau of the State Department shows the call, but no action is indorsed thereon, thus corroborating the belief that it was not sent.

When the *Northern* Boundary Commission was created, in 1872, Mr. Archibald Campbell was appointed United States commissioner of *that* survey also. He found at the outset that it was desirable to have for reference the records of the *Northwestern* Boundary Survey, and accordingly wrote to the State Department asking permission to withdraw those records for temporary use.

The following is a copy of his letter, which is now on file in the Index Bureau of the State Department:

U. S. NORTHERN BOUNDARY COMMISSION,
Washington, D. C., June 27, 1872.

SIR: In preparing for the duties of the boundary commission it would be of the greatest assistance to have the use of the records, notebooks, and other papers of

[1] G. M. Wheeler, U. S. Geog. Surv. W. One Hundredth Mer. 4°. Washington, 1889, vol. 1, p. 617.

the Northwest Boundary Commission, deposited by me in the Department at the close of the work in October, 1869.

I have therefore the honor to request that you allow me to withdraw these records and papers temporarily. Before leaving for the field they will be returned to the Department.

I have the honor to be, very respectfully, your obedient servant,

ARCHIBALD CAMPBELL,
Commissioner, Northern Boundary Survey.

Hon. CHAS. HALE,
Acting Secretary of State.

Upon that letter is indorsed: "Papers, etc., herein referred to sent to Mr. Campbell 27th June."

A search of the records of the Index Bureau of the State Department fails to reveal any other entry touching these papers. If they were returned no record was made of such return. It is certain that these papers were in the possession of the Northern Boundary Commission in 1872. Beyond that there is no trace. It would therefore be natural to look for them among the papers of the Northern Boundary Commission, which were sent to the State Department on June 30, 1876. But a search among these papers made by me in March, 1900, was unsuccessful. The missing manuscript was not found.

Prof. C. L. Doolittle, now at the Flower Observatory at Upper Darby, Pennsylvania, was connected with the Northern Boundary Survey. In response to an inquiry as to whether he had any information touching the report desired, he writes, among other things, under date of March 12, 1900:

My connection with the northern boundary began after active operations had been going on for a year. We then had our office at Detroit. After field operations were completed we removed to Washington. It is not a great exaggeration to say that I saw every scrap of paper to be found in the Detroit office. At all events, this report was not to be found there. I remember hearing such a report spoken of, but it was then said to be stored away with other Government archives at Washington.

(c) Archibald Campbell, the commissioner, died in the city of Washington July 27, 1887. To his son, Charles Campbell, now an employee in the Department of State, I am indebted for information as to the survey. I have also conferred with Gen. J. G. Parke, Corps of Engineers, U. S. A. (retired), who was chief astronomer and surveyor of the Northwestern Boundary Survey Commission, and with Mr. William J. Warren, chief clerk in the office of the Chief of Engineers, U. S. A., who was secretary of the commission. To both of these gentlemen, and especially to the latter, I am indebted for information used in preparing this account. Mr. G. Clinton Gardner, the assistant astronomer and surveyor from 1857 to 1868, is now a civil engineer in Peru, South America, while Mr. Joseph S. Harris, general assistant Northwest Boundary Survey from 1857 to 1864, is now president of the Philadelphia and Reading Railroad. To both of these gentlemen I am indebted for letters relating to the boundary and its survey. I have

also talked on this subject with Mr. J. V. Wurdemann, now employed in the Library of Congress, who participated in the survey and with Dr. Theodore Gill, who prepared a report on the fishes collected by the survey. To the courtesy of these gentlemen as also to that of Prof. C. L. Doolittle, to the Smithsonian Institution, to the Coast Survey, and to the General Land Office I am indebted for bits of information used in preparing this report.

ESTABLISHMENT OF THE LINE.

The present boundary line between British Columbia on the north and Washington, Idaho, and Montana on the south was established in 1846. Prior to that date the boundary was in dispute between the United States and Great Britain and the Oregon question was a burning one. Great Britain claimed as far south as forty-two degrees north latitude, the northern limit of California to-day. The United States claimed as far north as 54° 40′, the present southern boundary of Alaska. The slogan of the day was "Fifty-four forty or fight." But there was no fight and no fifty-four forty. A treaty was arranged by which the disputed tract was divided between the claimants. The boundary line adopted was the present line along the forty-ninth parellel from the summit of the Rocky Mountains to the middle of the channel between Vancouver Island and the continent and thence southward along the main channel and Juan de Fuca Strait to the Pacific.

The diplomatic agents who drew this treaty were, on the part of the United States, James Buchanan, then Secretary of State, and on the part of Great Britain, the then British minister, Richard Pakenham. The treaty was signed at Washington June 15, 1846, ratifications exchanged at London July 17, and proclaimed August 5, 1846.[1]

The first article of the treaty describes the boundary in the following words:

> From the point on the 49th parallel of north latitude, where the boundary laid down in existing treaties and conventions between the United States and Great Britain terminates, the line of boundary between the Territories of the United States and those of Her Britannic Majesty shall be continued westward along the said 49th parallel of north latitude, to the middle of the channel which separates the continent from Vancouver's Island and thence southerly through the middle of the said channel, and of Fuca's [Juan de Fuca] Straits, to the Pacific Ocean.

HISTORY OF THE SURVEY.

On August 11, 1856, almost exactly ten years after the proclaiming of the treaty of limits, which for brevity may be called the Buchanan-Pakenham treaty, Congress passed an act to carry its first article into effect. This act provided for the appointment of a commissioner and a chief astronomer and surveyor on the part of the United States to unite

[1] Stat. L., vol. 9, pp. 869-870; vol. 11, p. 42.

with similar officers to be appointed by Great Britain to survey the boundary and mark it with monuments. It also provided for the appointment of an assistant astronomer and surveyor, a secretary, and a clerk; it appropriated $11,000 for the annual salary of these five officers, and $60,000 for provisions, transportation, and contingencies; it restricted the work to the northern boundary of Washington, which then extended from the Rocky Mountains to the Pacific; and finally it authorized the President to direct the employment of such officers, assistants, and vessels of the Coast Survey as he might deem necessary or useful.

Under this law Mr. Archibald Campbell was appointed commissioner on February 14, 1857, and on the same day Lieut. (now Gen.) John G. Parke, Corps of Engineers, U. S. A., was appointed chief astronomer and surveyor,[1] each at a salary of $3,000 per annum. Two weeks later, viz, February 28, 1857, Mr. G. Clinton Gardner was appointed assistant astronomer and surveyor, and on April 5 entered upon his duties. On April 9 Mr. William J. Warren (now chief clerk Office of Chief of Engineers, U. S. A.) was appointed secretary, and on March 6 Mr. John J. Major was appointed clerk to the commissioner. Mr. Campbell remained commissioner to the end in 1869. On the outbreak of the civil war, in the spring of 1861, General Parke left the work and never returned to it. Messrs. Gardner and Warren served with the commission until December 31, 1868, and perhaps a little later.[2] Mr. Major resigned December 9, 1864.

Of the other principal employees, Mr. Joseph S. Harris, now president of the Philadelphia and Reading Railroad, is recorded as assistant surgeon and naturalist March 27, 1857, to March 31, 1864, when he left the survey to engage in private business. Francis Herbst and Henry Custer served as topographers, the former about two years from April 16, 1857, till March 31, 1859, the latter about seven years from April 16, 1857, till June 30, 1864. Mr. J. Nevine King served as quartermaster and commissary from May 21, 1857, to January 15, 1861; Mr. George Gibbs as geologist and interpreter from June 22, 1857, till May 31, 1862, and Mr. R. V. Peabody as guide from August 1, 1857, to January 15, 1861. Dr. C. B. R. Kennerly served as surgeon and naturalist from March 22, 1857, till his death in 1861.

On February 28, 1857, Mr. Campbell received his instructions from the Secretary of State, dated February 25, whereupon, he says, "I proceeded at once to collect all such information within my reach which might contribute to a proper understanding of the meaning of the language of the treaty, and in the execution of the work intrusted to me.[3] Having arranged with Professor Bache, Superintendent of the Coast Survey, for the use of the surveying steamer *Active* and the brig

[1] House Ex. Doc. No. 86, Fortieth Congress, Third session, p. 100.
[2] House Ex. Doc. No. 86, Fortieth Congress, Third session, p. 23.
[3] Senate Ex. Doc., No. 29, Fortieth Congress, second session, p. 8.

Fauntleroy, with the officers and assistants attached,[1] Mr. Campbell sailed from New York April 20 and reached San Francisco via the Isthmus of Panama on May 15. On June 17 the party sailed on the *Active* for Victoria, where they arrived five days later and learned that the first British commissioner, Capt. James Charles Prevost, R. N., commanding H. B. M. S. *Satellite*, had arrived at Esquimalt ten days before. The second British commissioner was Capt. George Henry Richards, R. N., whose ordinary duties were those of chief astronomer and surveyor, he being empowered to act as commissioner only in the event of the death of Captain Prevost. Captain Richards, commanding the British steamer *Plumper*, left England at the close of March, 1857, for Victoria. By an accident to the *Plumper's* machinery he was delayed at Rio de Janeiro for some time and did not reach Victoria till November, 1857. The powers of these first and second British commissioners did not extend to the whole line, but only to the water boundary. "So much of the boundary between her Majesty's possessions in North America and the territories of the United States as is comprised between the continent of America and Vancouver's Island." Such is the language of the instructions to Captain Prevost.

The British and American commissioners held their first meeting on Saturday, June 27, 1857, on board the *Satellite* in Esquimalt harbor. The respective commissions of themselves and assistants were exhibited, read, and found in due form. A second meeting was held three weeks later in Nanaimo harbor on board the *Satellite*. Captain Richards not yet having arrived, it was decided that nothing further could be done with the water-boundary question.

Accordingly the American party proceeded to the vicinity of the forty-ninth parallel at Point Roberts on the mainland and began operations on the land boundary. It was not till the summer of the next year, 1858, that the British commissioner for surveying the land boundary, Col. J. S. Hawkins, Royal Engineers, arrived from England. The American parties worked, therefore, alone during the fall and winter of 1857 and spring of 1858. "Before the spring [of 1858] four astronomical points on the 49th parallel were determined, and the country thoroughly reconnoitered in the vicinity of the parallel, for a considerable distance eastward."[2]

After the arrival of Colonel Hawkins a joint meeting of the commission was held to arrange a plan of field operations for surveying and marking the line. The outcome of that meeting is set forth in the following agreement:[2]

After discussing plans for determining and marking the line as far eastward as the Cascade Mountains, it was concluded to be inexpedient at the present time, in con-

[1] From Coast Survey Report for 1857, p. 116, we learn that, "At request of State Department," steamer *Active* and party, in charge of Lieut. Commander Richard M. Cuyler, U. S. N., were placed at disposal of Archibald Campbell, esq., commissioner of the Northwestern Boundary Survey.

[2] House Ex. Doc. No. 86, Fortieth Congress, Third session, p. 95.

sequence of the great expense, consumption of time, and the impracticable nature of the country, to mark the whole boundary by cutting a track through the dense forest.

It was therefore agreed to ascertain points on the line by the determination of astronomical points at convenient intervals on or near the boundary, and to mark such astronomical stations or points fixed on the parallel forming the boundary by cutting a track of not less than 20 feet in width on each side for the distance of half a mile or more, according to circumstances. Further, that the boundary be determined and similarly marked where it crosses streams of any size, permanent trails, or any striking natural feature of the country.

In the vicinity of settlements on or near the line it is deemed advisable to cut the track for a greater distance and to mark it in a manner to be determined hereafter.

This arrangement for the part west of the Cascades appears to have been subsequently applied to the whole line; and thus it resulted that of the entire boundary, 409.5 miles long, from the boundary station on the crest of the Rocky Mountains westward to the obelisk on the western side of Point Roberts, 190 miles were cleared and marked and 220 miles were not traced out, cleared, surveyed, or marked. These figures are obtained by scaling off from the final maps.

At the end of the season of 1858 the line had been reconnoitered eastward as far as the valley of the Skagit, near the one hundred and twenty-first meridian, a distance of about 90 miles, and the astronomical observations necessary for determining three points on the parallel in the valley of the Chiloweyuck completed.

In the season of 1859 the work of surveying and marking the boundary was carried eastward from the valley of the Skagit to the Columbia River, a distance of about 150 miles. General Parke, writing November 12, 1859, thus summarizes the work done during the season:

A completion of the determination and marking of the parallel from three points astronomically fixed at the close of the last season.

A complete set of observations for latitude at four stations, from which the parallel has been determined and marked at the crossings of the following streams: The Skagit, Pasayten, Similkameen, Okinakane (Lake Osoyoos), and Nehoialpitkwu; and before the astronomical parties leave the field the necessary observations will be completed for determining two other points of the parallel, the third crossing of the Nehoialpitkwu and the Columbia River.

A chronometer trip for difference of longitude between Camp Simiahmoo and Chiloweyuck depot.

Observations of the transit of the moon and moon-culminating stars at two of the latitude stations for absolute longitude.

A triangulation covering an area of about 50 square miles.

A survey of the nearest practical lines to the parallel, connecting the astronomical stations, making a total distance chained of about 370 miles.

Reconnoissances for developing the topography along and adjacent to the boundary line, and for locating routes of communication. These reconnoissances have extended over an area of about 6,000 square miles.

A full set of magnetic observations were made at one station, and throughout the work all the necessary observations for time, azimuth, micrometer value, and instrumental corrections were carefully made.

In the season of 1860 the surveying and marking of the entire land boundary was nearly or quite completed. I have not found any statement as to just when the field work ended. The Auditor's accounts indicate that a considerable number of laborers, axmen, packers, etc., were employed during 1861, of whom 22 were discharged on March 31 and 14 on June 30. Others received their final pay at various dates in 1861, the latest being in September. General Parke, who came out with the last party, tells me that on reaching the Columbia Plains he heard of the first battle of Bull Run. It seems to me likely, therefore, that the field work closed late in 1860 or early in 1861. During this season, then, the surveying and marking of the line was carried on over a distance of 170 miles—between the summit of the Rocky Mountains and the Columbia River.

As to the disbanding of the field parties and their return to Washington we gather some facts from the Auditor's accounts, so often cited here. It appears that all returned via the Isthmus of Panama, the fare being $258 from San Francisco to New York and $7.50 from New York to Washington. Commissioner Campbell, Secretary Warren, Geologist Gibbs, and Artist Alden left the field November 25, 1860, and reached Washington January 10, 1861, the journey taking forty-six days. Henry Custer, Charles T. Gardner, T. Hudson, and James Nooney left the field April 30, 1861, and G. Clinton Gardner on May 10, 1861. All these came direct to Washington. Finally, in the last quarter of 1861 (exact date not given), General Parke, J. S. Harris, J. V. Wurdemann, and John J. Major returned to Washington. With these returning parties came instruments, records, collections, baggage, etc. There is a charge for freight on "41 packages instruments and baggage" and "24 boxes natural-history specimens."

Arrived in Washington, the commission rented rooms and established an office over a store at the SE. corner of Pennsylvania avenue and Twentieth street NW., and there proceeded with the plattings, computations, drawing of maps, and preparation of the final report. The scientific reports appear to have been completed in 1862 and the drawing of the final maps, at least of the land boundary, late in 1865 or early in 1866. The work upon the report, however, continued, and there began to be some good-natured raillery as to when it would be completed. Finally, on January 13, 1869, the House of Representatives, by a resolution, requested information as to expenditures on account of the Northwestern Boundary Survey. The reply to that request has furnished the chief source of information for this history.[1] In October, 1869, the work was brought to a close and the results deposited in the State Department. But the report, unfortunately, was not published, and the manuscript has for many years

[1] House Ex. Doc. No. 86, Fortieth Congress, third session.

been lost to view. Its whereabouts are still unknown. The reason it was not published, I am informed, is that Mr. Fish, Secretary of State at that time, deemed its publication too expensive. The war had brought a mountain of debt, and under these conditions he refused to sanction so costly a publication.

COST.

The total cost of surveying and marking the line, including all expenses, was about $600,000, or $1,463 per mile. The first appropriation for the work, made August 11, 1856, was $71,000. This and the subsequent appropriations are as follows:

Appropriations for surveying and marking the boundary along the forty-ninth parallel, between the United States and the British Possessions, from the Rocky Mountains to the Pacific Ocean.

Date.	Fixed salaries.	Other expenses.	Total.	Authority.
August 11, 1856	$11,000	$60,000	$71,000	Stat. L., vol. 11, p. 42.
February 7, 1857	11,000	60,000	71,000	Stat. L., vol. 11, pp. 159–160.
June 5, 1858	11,000	60,000	71,000	Stat. L., vol. 11, p. 312.
March 3, 1859	11,000	139,000	150,000	Stat. L., vol. 11, pp. 403–404.
May 26, 1860	11,000	139,000	150,000	Stat. L., vol. 12, pp. 20–21.
Total	55,000	458,000	513,000	

The amount actually expended somewhat exceeded this sum, aggregating nearly $600,000.

In response to the House resolution of January 13, 1869, above referred to, Mr. Seward, then Secretary of State, transmitted, on February 9, 1869, a detailed reply, consisting, in the main, of a statement by Mr. C. M. Walker, then Fifth Auditor of the Treasury Department, of "disbursements on account of Northwest Boundary Survey from February 14, 1857, to December 31, 1868."[1] The total expenditures in that period were for—

Salaries	$385,508.78
Contingent expenses	209,724.25
Total	595,233.03

Most of these were made in the five years 1857 to 1861, inclusive. After the latter year a small office was maintained in Washington at an annual rental of $250, which, with various minor items, entailed an annual expense of from $1,200 to $1,400. The work was finally closed up and the records deposited in the State Department in October, 1869.[2]

[1] *House Ex.* Doc. No. 86, Fortieth Congress, third session, 102 pp.

[2] *Letter from Archibald* Campbell to Acting Secretary of State, June 27, 1872.

For the preparation of scientific reports on magnetics, mammals, birds, fishes, plants, insects, fossils, etc., including the making of drawings, there was expended about $3,500[1] and for the drawing of the final maps about $9,400.

For building the initial monument at Point Roberts was paid $7,590.38, one-half of which was paid by the United States and one-half by Great Britain.[2]

The cost to the British Government of running and marking the boundary line I have not found. A single item bearing on the matter is contained in Parliamentary Papers, 1863, volume 37, page 287 (55–v), where there is "An estimate of the sum required to be voted in the year ending March 31, 1864, to complete the expenses of surveying the line of boundary between the British and United States territory in the western part of North America, 4,300 pounds."

While the boundary survey was going forward there was another independent exploration by the British in progress in the region, under the direction of Capt. John Palliser. Early in 1857 the president of the Royal Geographical Society recommended to the British foreign office that a grant of £5,000 be voted to cover the expense of two years' exploration along the forty-ninth and fifty-third parallels and between the one hundredth and one hundred and fifteenth meridians.[3] This sum was voted and later on £1,500 additional, to continue the work one year more, making three years in all. Among the estimates for the year ending March 31, 1861, is an item of £6,300 for completing Palliser's explorations. The results of Palliser's work, his route of travel, etc., are set forth in the Journal of the Royal Geographical Society of London, 1859, volume 29, pages xcvii–c; and 1860, volume 30, pages 267–314.

MAPS.

ORIGINAL MANUSCRIPT MAPS.

Two large blue chests in the manuscript room at the State Department contain the original observations, computations, sketches, notes, etc., relating to the Northwestern Boundary Survey. They do not contain the final maps, these being kept among the treaty maps. They do, however, contain the following manuscript map material, which may be classified as preliminary and final:

Preliminary.—First. Several rolls of rough sketches of reconnoissances, triangulation, trails, office plattings, field sketches, etc., on rough paper, drawing paper, tracing linen, and tracing paper. Some of this is original field material identified by title, date, and signature. Much of it, however, is of the nature of office studies, plattings, etc., which served a temporary purpose and is no longer of value.

[1] House Ex. Doc. No. 86, Fortieth Congress, third session, p. 101.
[2] Same, p. 97.
[3] *Parliamentary* Papers, 1857, vol. 26, p. 29 (38-vii-sess. 2).

Second. There is a series of 19 sheets on tracing linen covering the entire line from the sea coast eastward to the Rocky Mountains. These sheets are numbered from west to east, 1 to 19. Each sheet except the first embraces 30′ of longitude and from 15′ to 25′ of latitude. Sheet 2, for example, includes from 123° to 122° 30′; sheet 3, longitude 122° 30′ to 122°, while sheet 19, the easternmost of the series, includes longitude 114° 30′ to 114°. The relief is shown by broken horizontal curves. The scale is not stated, but the parallels and meridians enable us to infer that it is 1:64000, or about 1 mile to 1 inch. These sheets bear no title, no legend, no date, and no names.

Third. There is a series of five manuscript maps (not numbered) on a scale of 1:120000, showing the entire line from the sea coast to the Rocky Mountains. They appear to be unfinished drafts. Relief is shown by contours in green, trails in red, and there are a few names. They are drawn on backed drawing paper. None of them have legends or titles, or names of draftsmen or any authority. They contain no dates. They appear to be compilations from original sketches, notes, and surveys. They are not numbered. Beginning at the west end of the line, the sheets cover the following areas: The first sheet covers from latitude 48° 40′ to 49° 25′, and from longitude 123° 20′ to 120° 50′, being 30 inches high and 61 inches wide. The second sheet covers from latitude 48° 33′ to 49° 35′, and from longitude 121° 15′ to 119° 12′, being 38 inches high and 50 inches wide. The third sheet covers from latitude 48° 30′ to 49° 18′, and from longitude 119° 35′ to 117° 40′, being 29 inches high and 50 inches wide. The fourth sheet covers from latitude 47° 35′ to 49° 10′, and from longitude 117° 50′ to 114° 40′, being 59 inches high and 55 inches wide. Owing to its inconvenient size this sheet has been cut into two pieces along the parallel of 48° 21′. The meridians are erroneously numbered. The fifth sheet covers from latitude 48° 15′ to 49° 35′, and from longitude 116° 08′ to 113° 13′, being 50 inches high and 71 inches wide. This map also has been cut into two pieces along the meridian of 114° 55′. Like the preceding, the meridians are erroneously numbered. Owing to its size, this roll of maps is not kept with the other material in the chests above mentioned.

Fourth. There is an unfinished manuscript map, in two sheets, on unmounted drawing paper, covering the entire line from the sea coast to the Rocky Mountains. It includes latitude 47° to 50° and longitude 113° 30′ to 125°, is on the conic projection, and is projected on the one hundred and nineteenth as the central meridian. The eastern part includes longitude 113° 30′ to 119°, the western 119° to 125°. The scale is not stated, but appears to be 1 : 601000. There is no title, no date, no signature. It is an outline map, no relief being shown. The camps are shown, but the boundary monuments are not.

Fifth. The foregoing four groups I have called preliminary maps. There is, however, a fifth group, a set of seven tracings, which have an official character which places them in a different category. These seven tracings, on tracing linen, are on a scale of 1:120000, are numbered from west eastward, and each sheet includes 1° 20′ of longitude and 30′ of latitude, being 15′ on each side of the forty-ninth parallel. Sheet 1, the westernmost, includes longitude 123° 10′ to 121° 50′; sheet 2, 121° 50′ to 120° 30′, and so on; and sheet 7, the easternmost, 115° 10′ to 113° 50′. On these maps are shown trails, camps, caches, monuments, and names; the relief also is shown by red contour lines.

Sheet 1 has the following legend:

Tracings numbering from 1 to 7, showing the topography, names, and scales adopted by the British and United States Boundary Commissions for their final maps. By order of the commissioners.

R. W. HAIG,
Capt'n R'l Art'y, Astr. British Commis'n.
G. CLINTON GARDNER,
Ass't Astr. and Surv., U. S. B. C.

WASHINGTON CITY, *May 30, 1863.*

Final drawings.—The final original manuscript maps resulting from the survey are thirteen in number. To this should be added the title page, making fourteen drawings. They are beautifully drawn on "smooth antiquarian" drawing paper, backed with muslin, and bound with blue braid. The sheets are of uniform size, being 30 inches high and 42 inches wide. They are kept among the treaty maps in the library of the Department of State. They are drawn wholly in black and show trails, timber, camps, monuments, etc. Topography is shown by hachures. The scale of the ten detailed maps is 1:120000, or 1.89 miles to 1 inch; of the two general maps 1:720000, or 11.37 miles to 1 inch, and of the index map 1:1200000, or 18.94 miles to 1 inch. This series of drawings was obviously planned to form an atlas. Of this the contents would be:

1. Title.
2. Index map showing location of ten detailed sheets.[1]
3. General map, eastern section.
4. General map, western section.
5. Detailed sheets numbered 1 to 7 (from east to west), showing land boundary.
6. Detailed sheets numbered 8 to 10, showing water boundary.

The title is as follows:

Maps of the Boundary between the United States and the British Possessions as established by the treaty of Washington, June 15, 1846. Surveyed under the direction of the Joint Commission appointed to carry into effect the First Article of the Treaty.

The index map is entitled:

Index Map showing the limits of the detailed sheets of the U. S. North Western Boundary Survey.

[1] The plate which accompanies this bulletin is a copy, on a reduced scale, of this map.

The general map (western section) has outside the border the legend "U. S. North West Boundary Survey, Archibald Campbell, U. S. Commissioner; John G. Parke, U. S. Eng., Chief Astr. and Surveyor." The title is as follows:

Map of Western Section. From notes by John G. Parke, U. S. Engineers, Chief Astr. and Surveyor, G. Clinton Gardner, Ass't Astr. and Surveyor, and Jas. S. Harris, Henry Custer, Chas. T. Gardner, George Gibbs, Francis Hudson and R. V. Peabody, Ass'ts U. S. Boundary Survey.

Compiled and drawn by Lemuel D. Williams, Theodor Kolecki, and Edward Freyhold. By order of U. S. Commissioner. (Signed) G. Clinton Gardner, Ass't Astr. and Surveyor, U. S. Boundary Survey, Office Washington D. C. 1866. Scale 1:720000 or 11.37 miles to one inch.

This map includes from longitude 118° to 125,° and the eastern section, bearing a similar title, includes from longitude 110° to 118°.[1]

The detailed sheets showing the land boundary, numbered 1 to 7, are signed "Jno. G. Parke, Major of Engrs., Brevet Major General, U. S. A., Chief Astr. and Surv. Archibald Campbell, U. S. Commissioner, etc. etc. etc. and J. S. Hawkins, Colonel R'l Eng'rs., H. B. M. Commissioner." The date of signing is recorded as May 7, 1869.

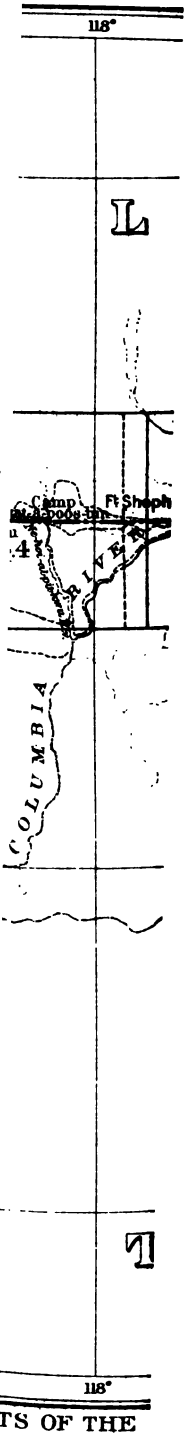
The detailed sheets showing the water boundary, numbered 8 to 10, have no titles, but each has the following written upon it: "That part of the boundary line described in the treaty of June 15, 1846, between the continent and Vancouver Island not agreed upon by the Joint Commission." These are signed by John G. Parke and Archibald Campbell. They do not bear the signature of any member of H. B. M. Commission. The date of signing is November 3, 1869.

Of these final maps, the seven detailed sheets showing the land boundary have been photolithographed and a small edition printed. Just when they were printed or how large the edition I have not learned. These photolithographs are on double the scale of the original (i. e., 1:60000). They were printed by the New York Lithographing, Engraving, and Printing Company, Julius Bien, superintendent. The sheets are numbered from east to west, and the seventh or westernmost bears the following title:

Photo-lithographic Copy of the detailed maps of the North West Boundary from Point Roberts to the Rocky Mountains between the United States and the British Possessions under the Treaty of June 15th, 1846, showing Monuments, Cuts, and other Marks. Archibald Campbell, U. S. Comr. N. W. Boundary Survey. Scale 1:60000 (enlarged to twice the scale of original drawings). Photo-lith. by New York Litho'g Engrav'g and Print'g Co., Julius Bien, Sup't.

The sheets are printed wholly in black, are 28 inches high by 71 inches wide and printed in two pieces. Relief is shown by hachures and timber by the usual convention. Boundary marks are shown by

[1] In the library of the Coast and Geodetic Survey I have seen a photograph of this western sheet. It is a pale and faded copy, 18 by 24 inches, was made by Alexander Gardner, and is on a scale of 1:1070000, or about 17 miles to 1 inch.



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black circles unaccompanied by names or any designations. Of these maps I have seen copies in the Library of Congress, in the Geological Survey, in the General Land Office, in the Office of the Chief of Engineers, and in the State Department. Some of these are numbered and others not. Could there have been two editions? These sheets cover less territory than the originals. They show the belt of topography, but omit the signatures and legends, if indeed there were any on the copy furnished the lithographer. The copy in the State Department has a clear, strong red line along portions of the boundary and under the title (sheet 7) has the following in the draftsman's hand:

NOTE.—The red lines indicate the portions of the boundary actually surveyed and marked by vistas cut through the forest and monuments of stone.

In the General Land Office there is a photographic copy of the detailed sheets dated 1866, on which are lines similar to the red ones above mentioned. As to this photographic copy we have the following statement made by Mr. Campbell in a letter to the Secretary of State, dated February 3, 1869:[1]

In collating the results of the survey * * * complete maps on a large scale [were] made of the entire boundary and the adjacent country. A general map has also been made, showing the extent of the country traversed. And to facilitate the survey of the public lands, photographic duplicates of the detailed sheets showing each monument on the boundary line, with its geographical position, were furnished to the General Land Office.

I have examined these photographs in the General Land Office. There are four of them, each 20 by 70 inches in size, and each composed of several separate photographs, which have been joined together, mounted on cloth, and bound with blue braid. A special title was prepared and photographed for each of these four maps. The title of the easternmost sheet is as follows:

Photographic Sketch of the detailed Maps of the Boundary between the United States and the British Possessions, showing the Monuments *from Mooyie and Yah'k Divide to Rocky Mountain Divide.* Mapped under the direction of the United States North West Boundary Commission. From Surveys by the Joint Commission to carry into effect the 1st Article of the Treaty between the United States and Great Britain and authorized on the part of the United States by Act of Congress of August 11th 1856.

Archibald Campbell, U. S. Commissioner.
John G. Parke, U. S. Eng., Chief Astr. and Surveyor.
G. Clinton Gardner, Ass't Astr. and Surveyor.
William J. Warren, Secretary.
John J. Major, Clerk.
Scale 1: 120000. 1866.

The titles of the others are identical with this, except as to the country covered. This easternmost sheet embraces longitude 113° 45′ to 116°, *from Mooyie and Yah'k Divide to Rocky Mountain Divide;*

[1] House Ex. Doc. No. 86, Fortieth Congress, third session, p. 96.

the next, longitudes 116° to 118½°, *from Inchuintum River to Mooyie and Yah'k Divide;* the next longitudes, 118½° to 121°, *from Divide of Cascade Mountains to Inchuintum;* and the last, longitudes 121° to 123¼°, *from Point Roberts to Divide of Cascade Mountains.*

The geographic positions of the various camps, stations, etc., are given on these maps, as are also the longitudes of the boundary monuments, accompanied by brief descriptions of the locations. These positions, classified in two groups and arranged in order of longitude, are printed on pages 28–39 of this bulletin.

The preparation of the 13 final original drawings was apparently begun in 1863. There is an autograph memorandum by Mr. G. Clinton Gardner, dated June 30, 1863, containing an estimate of the time required to make these drawings. He estimates that the drawing of seven sheet of 1:120000 scale will take eighty-two weeks' work, and that two sheets of the general map of 1:720000 scale thirty-five weeks' work. After discussing methods and costs he adds:

> The scale spoken of by the English commissioner for the general map was 1:600000, but that scale would require larger sheets than those used for the detailed maps. I have therefore proposed to use for the general maps 1/6 instead of 1/5 of that of the detailed maps in order that all the sheets shall be of uniform size.

As to the drawing of these sheets and their cost, there are three memorandums in the handwriting of Mr. Gardner. The first, undated, is as follows:

Seven detail sheets from Point Roberts to Rocky Mountains, at $600	$4,200
The water-boundary sheet	1,800
The two general sheets, one from Columbia River west	1,500
And the other from Columbia east to Fort Benton	1,000
	8,500

The second memorandum, dated October 31, 1864, is as follows:

The seven detail sheets have cost $4,085, [and] when completed [will cost] $115 [more]	$4,200
The general sheets have cost $1,867, [and] when completed [will cost] $813 [more]	2,500
The water-boundary sheet has cost $750, [and] when completed [will cost] $925 [more]	1,675
Total	8,375

The third memorandum, dated January 1, 1865, is as follows:

Water-boundary sheet	$2,000
Detail sheets, 7 at $600	4,200
General maps, No. 1, $1,800; No. 2, $1,400	3,200
Total cost of the drawing of maps	9,400

Thus it appears that the drawing of these maps was completed late in 1864 or early in 1865. The photographic copy of them in the General Land Office is dated 1866.

The drawing was done by Edward Freyhold, of No. 44 Sharp street, Baltimore, by L. D. Williams, and by Theodor Kolecki. Freyhold did the "hill work"—i. e., the hachures—and the others the outline, lettering, etc. Prior to February, 1864, Freyhold had drawn the hill work on detail sheets 3 and 7.

Among the papers is an unexecuted contract (apparently the original draft) between the United States Northwestern Boundary Commission and Edward Freyhold, whereby Freyhold agrees to draw the hill work on sheets 1, 2, 4, 5, and 6 "similar and not inferior to certain other work executed by him on sheets 3 and 7" for $1.75 per square inch, and to complete the work "before the 31st day of August, 1864."

Sheet 4 was finished March 5, 1864, and contained 214½ square inches of hill work; sheet 6 was finished April 26, 1864, and contained 249½ square inches of hill work; sheet 5 was finished June 6, 1864, and contained 137$\frac{5}{16}$ square inches of hill work; sheet 2 was finished August 13, 1864, and contained 225$\frac{1}{64}$ square inches of hill work. There is no record as to No. 1, but it is probable that it was finished on March 5, so that the hill work was all completed by August 13 and the drawing of the final maps completed about the beginning of the year 1865.

BRITISH MAPS.

On June 23, 1871, Sir Edward Thornton, then British minister in Washington, sent to the Department of State an atlas comprising maps, views, and tables of geographic positions of the northwest boundary. This atlas is entitled:

Maps of the land boundary between the British possessions in North America and the United States as established by the treaty of Washington, 15th June, 1846, and surveyed and marked under the direction of the Joint Commission appointed to carry into effect the 1st article of the treaty. Scale 1:120000, or 1.8939 statute miles to one inch. Photo-zincographed at the ordnance survey office, Southampton, under the superintendence of Cap't. Parsons, R. E., F. R. A. S.; Col. Sir Henry James, R. E., F. R. S., etc., director, 1869.

Then follows:

(a) An index map composed of two double-page sheets on a scale of 1:600000.

(b) Seven detailed sheets, scale 1:120000, numbered 1 to 7 from west to east. All are dated May 7, 1869, and signed by J. S. Hawkins, H. B. M. Comm'r, Archibald Campbell, U. S. Comm'r, Samuel Anderson, Lt. R. Eng'rs Secretary for Captain Haig, R. A., Chief Astronomer. Sheets 1 and 7 were drawn by J. Carroll, 2 by H. Walthouse, and 3, 4, 5 and 6 by F. B. Grose.

(c) A title page for another series of six sheets on the mile scale is as follows:

Maps of the land boundary between the British possessions in North America and the United States as established by the treaty of Washington 15th June, 1846, and

surveyed and marked under the direction of the Joint Commission appointed to carry into effect the 1st article of the treaty. Scale of 1:63360 or one statute mile to one inch. Photo-zincographed at the ordnance survey office under the superintendence of Captain R. M. Parsons, R. E., F. R. A. S.; Col. Sir H. James, R. E., F. R. S., etc., director, 1869.

The six sheets following this are numbered 1 to 6, from west to east, and are signed "J. S. Hawkins, colonel, Royal Engineers, H. B. M. commissioner, 7th May, 1869." The geographic coordinates of camps and stations are given; topography is shown by hachures, trails are shown in brown, and water in blue. Iron monuments are shown by a square symbol (■) and stone monuments by a round one (●). The vistas and cleared part of the line appear to be indicated by two lines, one down on each side of the parallel, thus, ═══.

(d) Between the title of the mile scale sheets and the sheets themselves are two double pages, the first containing ten photographic views of monuments and vistas, as follows:

Initial monument, stone obelisk, Point Roberts, four views, one of each face.
Boundary monument, Mooyie River.
Boundary monument and cutting, Kootenay East.
Boundary monument and cutting, Yak'h River.
Boundary monument and cutting, Kish-e-nehn.
Boundary monument, watershed Rocky Mountains, looking north.
Boundary monument, watershed Rocky Mountains, looking south.

The second double page contains two tables of geographic coordinates, with descriptions of stations. These tables are printed in this bulletin, pages 29, 31, 33, 35, 37, and 39.

According to these tables there are 161 monuments, marking parts of a boundary line 410 miles long. These are:

Stone obelisk	1
Iron pillars	42
Pyramids of stones	3
Bench marks	2
Mound of earth	1
Piles of stones	112
Total	161

(e) Lastly we have this double title page:

Maps to illustrate the boundary line established by the convention of London, 20th October, 1818, and the treaty of Washington, 15th June, 1846, between the British Possessions in North America and the United States, compiled from the following authorities:

* * * * * * *

Scale of .0528 inches to 1 statute mile, or 1:1200000. Photozincographed, etc. 1869.

This is followed by three double-page photographic maps showing the country between the forty-fifth and fifty-first parallels of north latitude and from the Pacific Ocean eastward to Minnesota.

GEOGRAPHIC COORDINATES.

The geographic positions of various camps and stations in the vicinity of the parallel were determined astronomically. Latitudes were determined with the zenith telescope; azimuth and time with the transit. Longitudes were determined by chronometer, by moon-culminating stars, and at one station, Camp Mooyie, by the solar eclipse of July 7, 1860.

It would seem that 28 fundamental or base stations were established near the boundary. For these stations measurements were made to the parallel. Thereupon other stations, with monuments, were established on the parallel.[1] Of these stations on the parallel there are 161. The description of these fundamental or base stations and of the 161 stations on the parallel, their location, longitude, etc., are given in Tables I to IV herewith. Tables I and III are made up from data on the photographic copies of the final map which were deposited in the General Land Office in 1866. Tables II and IV are copied from the British atlas in the State Department, which was presented by the British minister, Sir Edward Thornton, in 1871. The results from the two sources are almost identical, but as they are not absolutely so, and as the originals are not conveniently accessible, it was deemed best to print, side by side, the results from these two sources.

[1] For method employed see Appendix A, pp. 64-65.

TABLE I.—*Geographical coordinates of camps, stations, etc.*

FROM AMERICAN SOURCES.

No.	Station.	Latitude.			Longitude.		
		°	′	″	°	′	″
1	Camp Akamina	49	00	52.2	114	03	34
2	Camp Kishenehn	49	00	02.6		21	09
3	Ford of Flathead River	48	57	01.1		24	26.6
4	Junction of trail to Wigwam Station	48	55	31.4		43	33.7
5	Wigwam Station	48	59	42.8		45	02
6	Camp Kootenay East	48	59	44.4	115	11	19.2
7	Yahk'h Station	48	59	55.4		38	51
8	Camp Mooyie	49	01	25.6	116	12	40.5
9	Mooyie trail monument	49	00	01.3		14	59.2
10	Acklew Cache, junction of trails	48	54	21.4		22	02.1
11	Camp Kootenay West	48	59	54.9		31	16.2
12	Kootenay Mountain Station	49	00	12.8	117	10	48.4
13	Pend d'Oreille Station	49	00	03.5		21	52.9
14	Fort Shepherd Station	49	00	00		37	19.4
15	Camp Columbia	48	59	49.1		37	41.8
16	Camp Statapoostin	49	00	13.96	118	16	15.6
17	Inchuintum Station	48	59	58.5		28	12.3
18	Camp Nehoialpitkun	48	59	02.9		44	28.5
19	Camp Osoyoos or Osoyoos Station	48	59	56.4	119	24	12
20	Camp Similkameen	48	59	12.0		34	53.2
21	Nais-nu-loh Station	48	59	52.9	120	00	18.8
22	Junction of trails, Naisnuloh	49	07	54.8		00	59.9
23	Camp Pa-say-ten	48	59	42.2		32	12.8
24	Junction of trails, Pa-say-ten Valley	49	09	38.8		33	38.9
25	Roche Station	48	59	49.8		39	14.8
26	Camp Skagit	49	00	01.8	121	02	45.2
27	Crossing of Skagit River on trail	49	07	42.7		08	29.2
28	Camp Chuch-che-hum	49	00	03.5		16	41.4
29	Camp Chiloweyuck	49	00	21.9		23	41.8
30	En-saw-kwatch Station	49	00	30		30	41.8
31	Sen-ch-say Station	49	00	34.3		36	15.4
32	Camp Tummeahai	49	02	04.9		47	34.4
33	Intersection of Whatcom and Lake trails	48	06	05.4		54	56.8
34	Chiloweyuck Depot	49	09	28.2		57	59
35	Camp Sumass	49	01	25.8	122	11	52.8
36	British Station	49				37	01.6
37	Camp Simiahmoo	49	00	43.1		45	30
38							

TABLE II.—*Geographical coordinates of camps, stations, etc.*

FROM BRITISH SOURCES.

No.	Station.	Latitude.			Longitude.		
		°	′	″	°	′	″
1	Camp Akamina and Station	49	00	52.0	114	03	34.0
2	Camp Kish-e-nehn	49	00	02.8	114	21	09.0
3							
4							
5	Wigwam Station	48	59	42.8	114	45	02.0
6	Camp Kootenay East	48	59	44.6	115	11	19.2
7	Yahk'h Station	48	59	55.4	115	38	57.0
8	Camp Mooyie	49	01	26.0	116	12	40.5
9							
10							
11	Camp Kootenay West	48	59	55.1	116	31	16.2
12	Kootenay Mountain Station	49	00	12.8	117	10	48.4
13	Pend d'Oreille Station	49	00	03.5	117	21	52.9
14	Fort Shepherd Station	49	00	00.0	117	37	19.4
15	Camp Columbia	48	59	50.4	117	37	41.8
16	Camp Stat-a-poos-tin	49	00	10.8	118	16	15.6
17	In-chu-in-tum Station	48	59	58.5	118	28	12.3
18	Camp Ne-hoi-al-pit-kwu	48	59	04.3	118	44	28.5
19	Camp O-so-yoos & O-so-yoos Station	49	00	00.9	119	24	12.0
20	Camp Simil-ka-meen	48	59	12.1	119	34	53.2
21	Nais-nu-loh Station	48	59	53.9	120	00	18.8
22							
23	Camp Pa-say-ten	48	59	42.6	120	32	12.8
24							
25	Roche Station	48	59	49.8	120	39	14.8
26	Camp Skagit	49	00	02.3	121	02	45.2
27							
28	Camp Chuck-che-hum	49	00	03.7	121	16	41.4
29	Camp Chiloweyuck	49	00	22.2	121	23	41.8
30	En-saw-kwatch Station	49	00	30.0	121	30	41.8
31	Sen-eh-say Station	49	00	34.3	121	36	15.4
32	Camp Tummeahai	49	02	04.9	121	47	34.4
33							
34							
35	Camp Sumass and Station	49	01	25.8	122	11	52.8
36	British Station	49	00	00.0	122	43	59.9
37	Camp Simiahmoo Observatory	49	00	43.1	122	45	30.0
38	Obelisk at Initial Point	49	00	00.0	123	03	53.0

TABLE III.—*Locations and longitudes of the boundary monuments.*

FROM AMERICAN SOURCES.

No.	Location of monument.	Longitude.
		° ′ ″
1	Divide of Rocky Mountains	114 03 28.4
2	Left bank of Kishenehn Creek	20 53.9
3	Near trail entering Boundary Pass	21 17.3
4	Second terrace, left bank of Flathead River	27 09.4
5	First bench, right bank of Flathead River	28 02.5
6	West bank of river	45 16.1
7	Hillside, west of river	45 42
8	Small creek, foot of mountain	115 03 28.7
9	Second plateau, left bank of river	10 11.6
10	Right bank of river	11 11.2
11	Brink of ravine, base of mountain	16 01.4
12	Side of hill	38 02.8
13	Ridge of hill	38 29.1
14	Flat, east side of river	39 10.5
15	Flat, west side of river	39 24.5
16	Flat, west of river	39 46.5
17	High bluff, left bank of creek	a116 11 24
18	Left bank of creek, water's edge	11 25.6
19	Plateau above creek	a11 54
20	Side of mountain, west side of valley	12 22.3
21		
22	Brow of first hill, right bank of river	31 05.9
23	Mountain slope, west side of valley	35 44.9
24	Bench, west side of river	117 08 55.9
25	Mark on face of rock on hillside	09 56.5
26	Right bank of river, meridian of Pend d'Oreille Station	21 52.9
27	Bench, west side of river	22 03
28	Sharp ridge, west side of river	22 54.8
29	Near east bank of river	36 59.4
30		
31	On brink of hill, west bank of river	37 36.2
32	On hilltop, west of Camp Columbia	38 49.1
33	On ridge	41 17.7
34	.....do	45 49.5
35	On ridge between streams	53 08.1
36	.....do	59 00.9
37	On slope of hill between streams	118 01 52.2
38	On slope of hill east	03 17.1
39	On hill between streams	05 15.8
40	On hill west side of stream	09 26

a Approximate.

TABLE IV.—*Locations, longitudes, and descriptions of the boundary monuments.*

FROM BRITISH SOURCES.

No.	Location of monument.	Longitude.	Description.	From what station determined.	No. in British Atlas.
		° ′ ″			
1	On the divide of the Rocky Mountains.	114 03 28.41	Pile of stones.	Camp Akamina and Station.	161
2	On left bank of Kishenehn Creek..	20 53.9	.....do.....	Camp Kishenehn.	160
3	Near trail entering Boundary Pass.	21 17.3	.....do.....	.....do.....	159
4	On first bench, right bank Flathead River.	27 09.4	.....do.....	.....do.....	158
5	On second terrace, left bank Flathead River.	28 02.5	.....do.....	.....do.....	157
6	Near west bank of river.....	45 16.1	.....do.....	Wigwam Station .	156
7	On hill west of river	45 42.0	.....do.....	.....do.....	155
8	At foot of mountains, left bank small creek.	115 03 28.7	.....do.....	Camp Kootenay East.	154
9	On second plateau, left bank river.	10 11.6	.....do.....	.....do.....	153
10	On right bank Kootenay River	11 11.2	.....do.....	.....do.....	152
11	On east brink ravine beyond which the mountains rise.	16 01.4	.....do.....	.....do.....	151
12	On hillside east of river	38 02.8	.....do.....	Yahk'h Station...	150
13	.....do.....	38 29.1	.....do.....	.....do.....	149
14	Near east bank of river	39 10.5	.....do.....	.....do.....	148
15	On west side of river	39 24.5	.....do.....	.....do.....	147
16	.....do.....	39 46.5	.....do.....	.....do.....	146
17	On high bluff, left bank.....	*a*116 11 24	.....do.....	Camp Mooyie.....	145
18	On left bank of creek close to water.	11 25.6	.....do.....	.....do.....	144
19	On plateau above creek	*a*11 54	.....do.....	.....do.....	143
20	On side of mountain, west side of valley.	12 22.3	.....do.....	.....do.....	142
21	On trail leading from the north to Cholemta.	14 59.2	.....do.....	.....do.....	141
22	On brow of first hill, right bank river.	31 05.9	.....do.....	Camp Kootenay West.	140
23	On side of mountain, west side of valley.	35 44.9	.....do.....	.....do.....	139
24	On bench, west side, South Fork Salmon River.	117 08 55.9	.....do.....	Kootenay Mt. Station.	138
25	On face of rock on ridge east.....	09 56.5	Bench mark..	.....do.....	137
26	Latitude mark, Pend d'Oreille Station.	21 52.9	Pile of stones.	Pend d'Oreille Station.	136
27	On bench, west side of river.....	22 03	.....do.....	.....do.....	135
28	On high ridge west	22 54.8	.....do.....	.....do.....	134
29	Near east bank of Columbia River.	36 59.4	.....do.....	Fort Shepherd Station.	133
30	Near east bank of river	37 05.2	.....do.....	Camp Stat-a-poostin.	132
31	On brink of hill, west bank Columbia River.	37 36.2	.....do.....	.....do.....	131
32	On hilltop, west of Camp Columbia.	38 49.1	.....do.....	.....do.....	130
33	On side of hill between streams....	41 17.7	.....do.....	.....do.....	129
34	.....do.....	45 49.5	.....do.....	.....do.....	128
35	.....do.....	53 08.1	.....do.....	.....do.....	127
36	.....do.....	59 00.9	.....do.....	.....do.....	126
37	On slope between streams.....	118 01 52.2	.....do.....	.....do.....	125
38	.....do.....	03 17.1	.....do.....	.....do.....	124
39	On hill between streams.....	05 15.8	.....do.....	.....do.....	123
40	On hill west side of stream.....	09 26.0	.....do.....	.....do.....	122

a Approximate.

TABLE III.—*Locations and longitudes of the boundary monuments*—Continued.

FROM AMERICAN SOURCES—Continued.

No.	Location of monument.	Longitude.
		° ′ ″
41	Side of mountain east of river	118 09 58.4
42	Gravel bench west of river	11 56.1
43	Near the trail to Colville	13 19.1
44	Point of ridge at bend of valley	14 21.0
45	North slope of mountain south of river	16 36.
46	High ridge south of river	18 45.4
47	High ridge south of Nehoialpitkwu River	21 36.8
48	.....do	22 18.6
49	In valley at base of mountain, south	24 07.2
50	.....do	25 38.2
51	In valley south of Nehoialpitkwu River	26 32.6
52	In valley east of Colville trail	27 40.8
53	Near edge of first plateau	28 40.8
54	First plateau west of river	29 48.7
55	First bench west of small creek	31 28.4
56	Summit between creeks	33 43
57	Divide in bend of the Nehoialpitkwu River	36 43.4
58	Sharp ridge between creeks	38 24.9
59	Northern slope of mountain	39 51.5
60	.....do	40 57.2
61	Open country east of Rock Creek	41 49.6
62	.....do	42 38.4
63	.....do	43 24.5
64	East of Colville trail	44 13.8
65	Foot of mountain, right bank of Nehoialpitkwu River	45 12.6
66	Point of ridge in bend of river	45 48.9
67	.....do	46 45.6
68	Foot of mountains south side of valley	48 27.3
69	Point of hill south of creek	51 14.9
70	Ridge between two creeks	52 26.6
71	.....do	53 06.6
72	.....do	55 05
73	.....do	55 58.2
74	Summit east of wagon road	56 58.9
75	In valley east of wagon road	59 33.6
76	High plateau south of Rock Creek	119 01 23
77	.....do	02 54.9

TABLE IV.—*Locations, longitudes, and descriptions of the boundary monuments*—Cont'd.

FROM BRITISH SOURCES—Continued.

No.	Location of monument.	Longitude.	Description.	From what station determined.	No. in British Atlas.
		° ′ ″			
41	On side of mountain east of Nehoialpitkwu River.	118 09 58.2	Pile of stones.	Camp Stat-a-poos-tin.	121
42	On a gravel ridge west of river.....	11 56.1	.....do	.....do	120
43	In valley near trail to Colville.....	13 19.1	.....do	.....do	119
44	On point ridge right side of valley.	14 21.0	.....do	.....do	118
45	On north slope of mountains south of river.	16 36.7	.....do	In-chu-in-tum Station and Camp Stat-a-poos-tin.	117
46	On high ridge south of river.....	18 45.4	.....do	.....do	116
47	.....do	21 36.3	.....do	.....do	115
48	.....do	22 18.6	.....do	.....do	114
49	In valley of Nehoialpitkwu south of river.	24 17.2	.....do	.....do	113
50	.....do	25 38.2	.....do	.....do	112
51	.....do	26 32.6	.....do	.....do	111
52	In valley near and east of Colville trail.	27 40.8	.....do	.....do	110
53	On first plateau west of river.....	28 40.8	.....do	Camp Ne-hoi-al-pit-kwu and In-chu-in-tum Station.	109
54	.....do	29 48.7	.....do	.....do	108
55	On first bench west of small creek..	31 28.4	.....do	.....do	107
56	On summit between two creeks....	33 43.0	.....do	.....do	106
57	On devide between Rock Creek and Nehoialpitkwu.	36 43.4	.....do	.....do	105
58	On sharp ridge between heads of tributary of Rock Creek.	38 24.9	.....do	.....do	104
59	On southern slope of mountain....	39 51.5	.....do	.....do	103
60	.....do	40 57.2	.....do	.....do	102
61	In open country east of Rock Creek.	41 49.6	.....do	.....do	101
62	.....do	42 38.4	.....do	.....do	100
63	.....do	43 24.5	.....do	.....do	99
64	East of and near Colville trail.....	44 13.8	.....do	.....do	98
65	At foot of mountain, right bank of Nehoialpitkwu River.	45 12.6	Mound of earth.	Camp Osoyoos and Camp Ne-hoi-al-pit-kwu.	97
66	On point of ridge in bend of Nehoialpitkwu River.	45 48.9	Pile of stones.	.....do	96
67	On point of ridge in bend of Nehoialpitkwu.	46 45.6	.....do	.....do	95
68	In valley of Nechoialpitkwu	48 27.3	.....do	.....do	94
69	On point of ridge south and east of creek.	51 14.9	.....do	.....do	93
70	On ridge between two creeks	52 26.6	.....do	.....do	92
71	On same ridge.....	53 06.6	.....do	.....do	91
72	.....do	55 05.0	.....do	.....do	90
73	.....do	55 58.2	.....do	.....do	89
74	On summit east of wagon road to Rock Creek.	56 58.9	.....do	.....do	88
75	In valley east of wagon road to Rock Creek.	59 33.6	.....do	.....do	87
76	On high plateau south of Rock Creek.	119 01 23.0	.....do	.....do	86
77	.....do	2 54.9	.....do	.....do	84

TABLE III.—*Locations and longitudes of the boundary monuments*—Continued.

FROM AMERICAN SOURCES—Continued.

No.	Location of monument.	Longitude.
		° ′ ″
78	High plateau south of Rock Creek	119 04 36
79	Rocky ledge east of small lake	06 15
80	Summit east of creek	08 02.8
81	West bank of creek	09 32.8
82	First bench west of creek	10 18.4
83	Slope of hill north of small lake	11 56.5
84	South and east of Colville trail	14 27.2
85	North and west of small creek	17 10.4
86	Spur from mountain to the north	18 58.1
87	.....do	21 26.4
88	Summit of first ridge east of the valley	22 37.6
89	East side of Osoyoos Valley	24 08.9
90	West side of Osoyoos Valley	26 04.5
91	Plateau north of Similkameen River	28 48
92	.....do	29 52.6
93	Southern slope of rocky knoll	33 24
94	Ridge east of trail	36 14.6
95	Near trail	37 45.9
96	Isolated mountain east of Similkameen River	39 56.6
97	Left bank of Similkameen River	40 32.7
98	Foot of mountains west side of Similkameen Valley	42 20.9
99	Flat east side of swamp	58 38.7
100	Near small stream	59 57.9
101	Sharp ridge west side of stream	120 00 46.1
102	Bench east side Pa-say-ten Valley	32 00.9
103	Slope west side Pa-say-ten Valley	32 29.3
104	Hillside east of Chuchuwanten River	38 51.9
105	Hillside west of Chuchuwanten River	39 47.2
106	Bench of hill east side of Skagit Valley	121 02 26.6
107	Slope of mountain west side of Skagit Valley	04 22.2
108	Base of mountain south of camp	16 41.4
109	West of and near trail to Skagit	16 56.3
110	East of and near trail to Skagit	18 57.3
111	East side of Klahaihu Valley	23 11
112	West side of Klahaihu Valley	23 48.5
113	East of river	30 08.4
114	On rock west of river	30 21.2

TABLE IV.—*Locations, longitudes, and descriptions of the boundary monuments*—Cont'd.

FROM BRITISH SOURCES—Continued.

No.	Location of monument.	Longitude.	Description.	From what station determined.	No. in British Atlas.
		° ′ ″			
78	On high plateau south of Rock Creek.	119 4 36.0	Pile of stones.	Camp Osoyoos and Camp Ne-hol-al-pit-kwu.	85
79	On rocky ridge east of small lake ..	6 15.0	.....do.....	.....do.....	83
80	On summit east of fork of Rock Creek.	8 02.8	.....do.....	.....do.....	82
81	On valley of fork of Rock Creek, west bank.	9 32.8	.....do.....	.....do.....	81
82	On first bench west of fork of Rock Creek.	10 18.4	.....do.....	.....do.....	80
83	North of small lake.....	11 56.5	.....do.....	.....do.....	79
84	Southeast of Colville trail	14 27.2	.....do.....	.....do.....	78
85	North and west of small creek	17 10.4	.....do.....	.....do.....	77
86	On spur from mountain to the north.	18 58.1	.....do.....	.....do.....	76
87	.....do.....	21 26.4	.....do.....	.....do.....	75
88	Summit of first ridge east of Lake Osoyoos.	22 37.6	.....do.....	.....do.....	74
89	East of trail up east bank of Lake Osoyoos.	24 08.0	.....do.....	.....do.....	73
90	West of trail up west bank of Lake Osoyoos.	26 04.5	.....do.....	Camp Similkameen and Camp Osoyoos.	72
91	Near divide between Osoyoos and Similkameen and near junction of trail.	28 48.0	.....do.....	.....do.....	71
92	On plateau north of Similkameen..	29 52.6	.....do.....	.....do.....	70
93	On southern slope of a rocky knoll.	33 24.0	.....do.....	.....do.....	69
94	On summit of ridge east of trail up Similkameen.	36 14.6	.....do.....	.....do.....	68
95	East of and near trail up Similkameen.	37 45.9	.....do.....	.....do.....	67
96	On summit of isolated mountain of Similkameen.	39 56.6	.....do.....	.....do.....	66
97	On left bank of Similkameen	40 32.7	.....do.....	.....do.....	65
98	At foot mountains west side Similkameen Valley.	42 20.9	.....do.....	.....do.....	64
99	On flat east side of stream.....	58 38.7	.....do.....	Nais-nu-loh Station.	63
100	East and near to stream.....	59 57.9	.....do.....	Nais-nu-loh Station.	62
101	On sharp ridge west side of stream.	120 00 46.1	.....do.....	.....do.....	61
102	On bench, east side of Pasayten Valley.	32 00.9	.....do.....	Camp Pa-say-ten.	60
103	On slope west side of Pasayten Valley	32 29.3	.....do.....	.....do.....	59
104	On hillside east of river.....	38 51.9	.....do.....	Roche Station....	58
105	On hillside west of station	39 47.2	.....do.....	.....do.....	57
106	On side of hill east of Skagit Valley.	121 02 26.6	.....do.....	Camp Skagit	56
107	On side of mountain west side of Skagit Valley.	04 22.2	.....do.....	.....do.....	55
108	At foot of mountain south of camp.	16 41.4	.....do.....	Camp Chuch-che-hum.	54
109	West of and near trail to Skagit ...	16 56.2	.....do.....	.....do.....	53
110	East of and near trail to Skagit	18 57.3	.....do.....	.....do.....	52
111	On east side of Klahaihu Valley ...	23 11.0	.....do.....	Camp Chiloweyuck.	51
112	On west side of Klahaihu Valley...	23 48 5	.....do.....	.....do.....	50
113	On east side of Ensaw-kwatch River.	30 08.4	.....do.....	En-saw-kwatch Station.	49
114	On west side of Ensaw-kwatch River.	30 21.2	Bench mark ↑	.....do.....	48

TABLE III.—*Locations and longitudes of the boundary monuments*—Continued.

FROM AMERICAN SOURCES—Continued.

No.	Location of monument.	Longitude.
		° ′ ″
115	East side of Sen-eh-say River	121 35 28.4
116	Side of mountain south of creek	42 56.3
117	.....do.	43 31.6
118	Side of mountain west of falls of creek	43 58.1
119	Whatcom trail (last iron pillar) *a*	122 04 45.2
120	Small bench east base of hill	05.26.6
121	Summit of hill east of Sumass Prairie	06 31.9
122	Bench above rocky precipice	07 21.7
123	Face of hill	07 50.4
124	Small bench west of stream	08 38.4
125	Flat east of stream	10 02.7
126	Rising ground	11 00.8
127	Meridian of Camp Sumass	11 52.8
128	East side of Sumass River	12 46.3
129	Trail west of Sumass River	12 55.2
130	Trail crossing boundary	14 01
131	Trail on sharp ridge west of swamp	15 04.1
132	Flat north of trail	16 29.1
133	Hill east of trail	18 00.6
134	East bank of small lake	19 08.9
135	Trail crossing boundary	19 55.1
136	West of swamp and north of trail	20 29.4
137	Flat north of trail	21 47.6
138	Trail crossing boundary	22 20.7
139	Trail east side of Cullam Creek	23 05.9
140	Flat south of trail	24 22.7
141	.....do	25 04.1
142	Rising ground between swamp and creek	27 19.3
143	Belt of timber between swamps	28 32.9
144	Edge of slope west of swamp	29 37.2
145	Trail west bank of Sehkomehkl Creek	30 07.9
146	Ridge west of Sehkomehkl Creek	31 05.1
147	Flat north of trail	32 13.7
148	Small ridge south of trail	33 27.7
149	Flat south of trail	34 46.7
150	Flat near stream, south of trail	36 08.5
151	Latitude mark, British station	37 01.6
152	First bench and south of trail	37 26.9

a A pencil note here says: "All iron pillars from western end to Whatcom trail—43 in all—36 given here."

TABLE IV.—*Locations, longitudes, and descriptions of the boundary monuments*—Cont'd.

FROM BRITISH SOURCES—Continued.

No.	Location of monument.	Longitude.	Description.	From what station determined.	No. in British Atlas.
		° ′ ″			
115	On east side of Sen-eh-say, or Selacee, River.	121 35 28.4	Pile of stones.	Sen-eh-say Station	47
116	On side of mountain south of creek.	42 56.3	Pyramid of stones.	Camp Tummea-hai.	46
117	.....do.....	43 31.6	.....do.....	.....do.....	45
118	On side of mountain west of falls of creek.	43.58.1	.....do.....	.....do.....	44
119	On De Lacy's trail, Whatcom to Fort Hope, crossing line.	122 4 45.2	Iron pillar....	Sumass Station and Camp.	43
120	On bench at base of hill	5 26.6	.....do.....	.....do.....	42
121	On top of mountain east side of Sumass Prairie.	6 31.9	.....do.....	.....do.....	41
122	On bench above rocky precipice east of trail.	7 21.7	.....do.....	.....do.....	40
123	On face of hill 5 chains from base and near trail.	7 50.4	.....do.....	.....do.....	39
124	On bench west of stream.....	8 38.4	.....do.....	.....do.....	38
125	On flat east of stream	10 02.7	.....do.....	.....do.....	37
126	On mound east of latitude mark...	11 00.8	.....do.....	.....do.....	36
127	Latitude mark Sumass	11 52.8	.....do.....	British Station ...	35
128	On east side of Sumass River	12 46.3	.....do.....	.....do.....	34
129	On Whatcom trail west side Sumass River.	12 55.2	.....do.....	.....do.....	33
130	On trail crossing boundary line....	14 01.0	.....do.....	.....do.....	32
131	On top of hill west of swamp and on trail crossing line.	15 04.1	.....do.....	.....do.....	31
132	On flat north of trail and west of swamp.	16 29.1	.....do.....	.....do.....	30
133	On hill 20 chains east of trail crossing line.	18 00.6	.....do.....	.....do.....	29
134	On east side small lake.....	19 08.9	.....do.....	.....do.....	28
135	On trail crossing boundary line....	19 55.1	.....do.....	.....do.....	27
136	On west side of swamp and north of trail.	20 29.4	.....do.....	.....do.....	26
137	On flat north of trail	21 47.6	.....do.....	.....do.....	25
138	On trail crossing boundary line....	22 20.7	.....do.....	.....do.....	24
139	On trail crossing boundary line east side of creek.	23 05.9	.....do.....	.....do.....	23
140	On flat south of trail.....	24 22.7	.....do.....	.....do.....	22
141	.. ..do.....	25 04.1	.....do.....	.....do.....	21
142	On slightly elevated ground west of creek.	27 19.3	.....do.....	.....do.....	20
143	On belt of timber between swamps.	28 32.9	.....do.....	.....do.....	19
144	On edge of slope west of stream and south of trail.	29 37.2	.....do.....	.....do.....	18
145	On trail crossing line west side of Seh-ko-mehl Creek,	30 07.9	.....do.....	.....do.....	17
146	On ridge west of Seh-ko-mehl Creek.	31 05.1	.....do.....	.....do.....	16
147	On flat north of trail.....	32 13.7	.....do.....	.....do.....	15
148	On ridge south of trail and stream .	33 27.7	.....do.....	.....do.....	14
149	On flat south of trail.....	34 46.7	.....do.....	.....do.....	13
150	On flat near stream south of trail...	36 08.5	.....do.....	.....do.....	12
151	Latitude mark, British station	37 01.6	.....do.....	.....do.....	11
152	On first bench south of trail.....	37 26.9	.....do.....	.....do.....	10

TABLE III.—*Locations and longitudes of the boundary monuments*—Continued.

FROM AMERICAN SOURCES—Continued.

No.	Location of monument.	Longitude.
		° ′ ″
153	Slope south of trail	122 38 45.5
154	Flat west of ravine	40 04.1
155	.....do	41 22.7
156	Small ridge between swamps	42 20.5
157	Parallel station	43 59.9
158	East side of Point Roberts	123 00 42.9
159	Ridge on Point Roberts	02 12.7
160	Flat east of Obelisk	03 02.9
161	Initial Point, Obelisk of stone	03 53

TABLE IV.—*Locations, longitudes, and descriptions of the boundary monuments*—Cont'd.

FROM BRITISH SOURCES—Continued.

No.	Location of monument.	Longitude.	Description.	From what station determined.	No. in British Atlas.
		° ′ ″			
153	On slope south of trail	122 38 45.6	Iron pillar	British Station	9
154	On flat west of ravine	40 04.1	do	do	8
155	do	41 22.7	do	do	7
156	On small ridge between swamps	42 20.5	do	do	6
157	Near high-water mark, Simiahmoo Bay.	43 59.9	do	do	5
158	On east side of Point Roberts	123 00 42.9	do	Camp Simiahmoo observatory.	4
159	On ridge	02 12.7	do	do	3
160	On flat east of Obelisk, Point Roberts.	03 02.9	do	do	2
161	On west face of Point Roberts	03 53.0	Obelisk	do	1

MAGNETICS.

Both the British and the American surveyors were equipped with an outfit of instruments for determining the magnetic declination, dip, and force. The British instruments were standardized at Greenwich, and the resulting elements at 23 stations, as obtained by Captain Haig, were discussed by General Sabine and published in the Philosophical Transactions. An abstract of these results is printed on page 42 of this bulletin.

As to the results by the American parties, much, unfortunately, must be left to inference, their results being, supposedly, in the "lost report." Mr. Campbell, writing in 1869,[1] says: "A magnetic survey extending over a range of 3° 20′ in latitude and 4° in longitude, with the necessary observations of the magnetic elements of the astronomical stations, was also made." The work appears to have been done by Mr. J. S. Harris, whose results were secured by the United States Coast Survey. From these it appears that the observations covered a considerably larger extent of territory than that above indicated by Mr. Campbell. The character of the instrumental outfit and its fate in the field can be inferred, in part, from the two following passages from General Parke's report of progress, written November 12, 1859: "A full set of magnetic observations were made at one station" (in 1858).[2] Also, "I am happy to report that we have got thus far through the season's work without any damage to our astronomical instruments. I regret, however, that we have been less fortunate with the magnetic instruments. The mule carrying these missed his footing and rolled down a precipitous bank. The magnetic theodolite will have to be replaced, and the other instruments will require repairing."[3]

The Coast and Geodetic Survey has furnished from its manuscript registers the following table of results for declination, dip, and intensity.

[1] House Ex. Doc. No. 86, Fortieth Congress, third session, p. 95.
[2] Senate Ex. Doc. No. 16, Thirty-sixth Congress, first session, p. 6.
[3] Same, pp. 6–7

Declination, dip, and force for the mean epoch 1860.

[Results from observations by Joseph S. Harris, United States Northwestern Boundary Commission, 1858 to 1861. From manuscript furnished by the United States Coast and Geodetic Survey.]

Station.	Latitude.	Longitude.	East declination.	Dip.	Horizontal force.		Total force.
					Br. units.	C. G. S. units.	C. G. S. units.
	° ′	° ′	° ′	° ′			
Magnetic station	49 00	114 21	22 58				
Do	48 59	115 10	22 58				
Camp No. 11	49 07	115 16		73 37			
Camp No. 14, Joseph Prairie	49 31	115 35	23 34	73 49	3.757	0.1732	0.6217
Magnetic station	49 00	116 33	22 37				
Do	48 42	116 19	22 16				
Do	48 10	116 45	21 49				
Peon Prairie	47 44	117 14	21 53	72 05	4.099	0.1890	0.6146
Spokane Ferry	47 49	117 49	22 07	71 52	4.132	0.1905	0.6123
Colville Depot	48 34	117 52	22 31	72 31	3.976	0.1833	0.6100
Tukannon River	46 32	118 00	20 55	70 22	4.380	0.2020	0.6009
Lugenbeel Creek	47 09	118 06	20 55	71 19	4.229	0.1950	0.6085
Cow Creek	46 53	118 10	21 01	71 01	4.301	0.1983	0.6097
Dry Creek	46 09	118 18	20 13	70 47	4.289	0.1978	0.6007
Magnetic station	46 03	118 25	20 00				
Do	49 00	118 44	22 07				
Near Wallula	46 02	119 00	19 46				
Camp Osoyoos	49 00	119 24		72 33			
Magnetic station	49 00	119 35	23 34				
Do	49 03	120 55	24 19				
Skagit	49 00	121 03		72 40	3.933	0.1812	0.6084
Magnetic station	49 05	121 07	22 23				
Camp Chiloweyuck	49 01	121 23	22 09	72 25	4.025	0.1856	0.6141
Magnetic station	48 59	121 42	22 47				
Do	49 01	121 45	22 55				
Do	48 59	121 57	22 39				
Semiahmoo	49 01	122 46	22 55	72 01	4.094	0.1888	0.6115
Point Roberts	48 59	122 58	22 39	71 46	4.111	0.1896	0.6056

Declination, dip, and force for the mean epoch 1860.

[Abstract of results obtained by Capt. R. W. Haig, R. A., with standard instruments, between August, 1858, and August, 1861, in connection with the survey of the northwest boundary. From Philosophical Transactions of the Royal Society, 1864, vol. 154, pp. 161-166.]

Station.	Latitude.	Longitude.	East declination.	Dip.	Total force.	
					Br. units.	C. G. S. units.
	° ′	° ′	° ′	° ′		
Akamina station	49 01	114 04	22 56	73 38	13.522	0.6235
Wigwam station	49 00	114 45	22 50	73 30	.496	0.6223
Tobacco Plains (Kootenay)	48 57	115 08	.....	73 24	.481	0.6216
On Kootenai River	48 40	115 17	22 36	73 09	.460	0.6206
South Crossing (Kootenay)	48 22	115 21	22 28	72 55	.443	0.6198
Chelemta	48 41	116 19	22 27	72 59	.428	0.6189
Pack River	48 22	116 28	22 19	72 43	.401	0.6179
Sinyakwateen	48 09	116 44	22 10	72 30	.288	0.6104
Chemikane River	48 00	117 45	21 57	72 12	.334	0.6148
Colville B. B. C. Barracks	48 40	118 05	22 11	72 39	.357	0.6159
Inshwointum	49 00	118 28	22 15	72 50	.361	0.6161
Osoyoos station	49 00	119 24	22 07	.....	.....	.....
Ashtnolou station	49 00	120 00	22 12	72 34	.306	0.6135
On Ashtnolou River	49 07	120 00	22 04	.....	.....	.....
Do	49 10	120 00	22 06	72 42	.315	0.6139
Dalles, 8-mile camp	45 40	120 49	.....	69 49	.091	0.6036
Dalles, 3-mile camp	45 35	120 49	20 27	69 45	.067	0.6034
Chiluweyuk	49 02	121 23	.....	72 21	.257	0.6113
Schweltza Lake	49 02	122 00	21 44	72 14	.234	0.6102
Sumass Prairie	49 01	122 12	21 42	72 11	.226	0.6098
Nisqually	47 07	122 25	20 51	70 39	.111	0.6045
Fort Vancouver	45 38	122 28	20 13	69 28	.026	0.6006
Esquímalt	48 26	123 27	21 20	71 30	.148	0.6062

ELEVATIONS.

Elevations were determined along and near the boundary by both the American and British parties throughout the progress of the survey. Most of them were measured barometrically; a few were determined by triangulation.

Among the State Department papers is a short summary or table of heights determined by the British, and a longer and incomplete list of elevations determined by the United States parties.

The British list, contained on two leaves of blue foolscap paper, is entitled: "Abstract of the principal heights determined by barometrical measurements on the line of the North American boundary in the years 1859, 60–61."

The table contains eight columns. The first gives the year; the second, name of station; third, latitude; fourth, longitude; fifth, barometer (always marked A or M, meaning probably aneroid or mercurial); sixth, number; seventh, elevation above sea level; eighth, how determined. The paper is not dated or signed. Columns 2, 3, 4, and 7 of that table are here printed on pages 43 and 44.

The American list is entitled: "Data concerning the determination of altitudes by the U. S. N. W. Boundary Commission in the years 1857, 58, 59, and 60."

This data is contained in two cahiers, of six double sheets each, designated Vol. I and Vol. II. The first one has been revised throughout; the second one is apparently revised in part only and is incomplete. The data is in nine columns. The first gives the date "when occupied;" the second, the name of station; third, barometer (designated by number, 790, 1224, 1219, 1226); fourth, number; fifth, latitude; sixth, longitude; seventh, observer; eighth, altitude; ninth, remarks. We here print columns 2 and 9 (consolidated), 5, 6, and 8.

Elevations along the forty-ninth parallel from the Pacific Ocean to the Rocky Mountains, determined barometrically, in the years 1857–1860, by the British Northwestern Boundary Commission.

No.	Station.	Latitude.	Longitude.	Elevation.
		° ′ ″	° ′ ″	*Feet.*
1	River about 2 miles below lower end of Chief Mountain Lake			5,028
2	Watershed in South Kootenai Pass			6,970
3	Mountain near following station			8,454
4	End of boundary line, watershed in latitude 49°	49 0 00	114 3 25	7,524
5	Terminal latitude station	49 0 52	3 34	6,548
6	Watershed on trail below Summit Station	49 1 26	3 54	5,859
7	Mule Camp	49 3 38	7 30	5,191
8	Junction of trails south of Kootenai Pass	49 5 39	11 42	4,753
9	Flathead latitude station	49 0 00	21 06	4,136
10	Ford of Flathead River	48 57 01	24 24	4,073
11	Flathead Valley, upper terrace	48 56 18	28 40	4,267
12	Wigwam River Station	48 59 43	45 02	4,694
13	Watershed, Tobacco and Wigwam	48 57 23	45 02	5,332
14	Camp [near head of Tobacco River, homeward]	48 53 06	45 43	4,350
15	Camp near head of Tobacco River [outward]			4,358
16	Camp on Tobacco River—homeward	48 49 04	53 52	2,998
	Camp on Tobacco River—outward			3,103
17	Mooyie cutting	49 00 00	116 11 40	2,252
18	Crossing of Mooyie River	48 54 08	11 38	2,142
19	Second ridge west of Yakh River	48 54 17	8 30	4,466
20	First ridge west of Yakh River	48 33 55	4 00	5,791
21	High peak above following station			8,531
22	Watershed, Kootanie and Yakh rivers	48 58 13	115 25 00	7,664
23	Watershed at head of Mooyie River	49 27 00	115 46 00	2,920
24	Yakh River Station	48 59 55	38 48	2,927
				2,998
25	Third crossing, Kootanie River on Tobacco plains near trading post	48 37 30	10 00	2,228
				2,296
				2,300
26	Second crossing, Kootanie River	48 22 01	26 30	2,136
27	Chelempta Kootanie River	48 41 15	116 34 24	1,712
28	Sinyakwateen Ferry	48 09 16	50 20	1,996
29	Lake 9 miles south of Sinyakwateen	48 00 03	52 00	2,192
30	Edge of wood, Spokane plains	48 48 35	117 00 45	2,143

Elevations along the forty-ninth parallel, etc.—Continued.

No.	Station.	Latitude.			Longitude.			Elevation.
		°	′	″	°	′	″	*Feet.*
31	Plants house	48	42	50	117	17	00	2,018
32	Little Spokan Springs	48	46	10		29	00	1,641
33	Spokan River—west bend	47	58	20		40	30	1,423
34	Chém-a-kane bridge	48	0	14	116	46	24	1,890
35	N. A. B. C. Barracks, at Colville, Columbia River	48	39	58	118	05	10	1,268 1,336
36	Fort Shepherd	49	01	05	117	36	58	1,405
37	Third boundary crossing of Colville River	48	58	26	118	13	28	1,534
38	Statapoostin Station	49	00	13		17	09	1,515
39	Camp 8½ miles below In-chú-in-tum Station	49	00	23		25	00	1,871
40	In-chú-in-tum Station	49	00	01		30	13	1,991
41	Camp on line near Rock Creek	48	59	30	119	02	10	2,351
42	Haigs Pond	49	00	00		8	40	3,784
43	Camp Archer, near Osoyoos	48	59	50		19	05	2,880
44	Larchtree Hill	49	00	00		13	00	3,964
45	Similkameen River, near Vermilion Forks							1,597
46	Camp above Similkameen							3,031
47	Camp near Moodys Flat							4,119
48	Camp 21 miles out on road							1,652
49	Fort Hope							*a* 140
50	Osoyoos Lake	49	00	00	119	26	40	757 928 949
51	Similkameen River							1,180
52	Haynes house	49	02	00	119	43	00	1,130
53	Similkameen—lower ford	49	12	05		53	10	1,244
54	Highest Ashtnolon Mountain	48	58	40	120	01	30	*b* 7,500
55	Ashtnolon Station	48	59	54		02	44	5,556
56	Upper Ashtnolon Ford	49	08	00		08	15	2,431
57	Ashtnolon Cache	49	07	20		19	20	3,556
58	Ptarmigan Hill	49	08	40		26	00	6,331
59	Mouth of Pasayten River	49	09	55		35	55	3,060
60	Roche River Station	48	59	50		41	20	4,300
61	Mouth of Roche River	49	08	30		44	40	3,774 3,459
62	Camp about 600 feet below summit on east side of Hozomeen: outward	49	02	05		59	30	5,538
	Hozomeen: returning							5,527
63	Summit of Hozomeen Pass	49	02	40	121	00	45	6,277
64	Skagit Ford	49	08	00		11	05	1,640 1,634
65	Chuchchehum Pass		00	20		17	40	4,719
66	Chiloweyuck Lake		01	30		25	10	2,052

a Assumed. *b* Approximate.

Elevations along the forty-ninth parallel from the Pacific Ocean to the Rocky Mountains, determined barometrically in the years 1857–1860 by the United States Northwestern Boundary Commission.

No.	Station.	Latitude.	Longitude.	Elevation.
		° ′	° ′	*Feet.*
1	Camp Simiahmoo	49 00.7	122 45.5	11
2	Camp Sumass	01.4	11.9	14
3	Sumass Creek, mouth of; by the creek and lake about 15 miles below Camp Sumass, about 57 miles from the sea; ordinary tides rise here about 1 foot	08.7	04.3	7
4	Mountains east of Pekosie Lake	48 58.5	01.0	4,991
5	Harrison Lake	49 19.1	121 43.4	30
6	Harrison or Shook-o-meh River, mouth of	.....	.....	20
7	Chiloweyuck River, near Hudson Bay Company fishery	.....	.....	15
8	Hach-tcha village, about 77 miles above mouth of Fraser River	.....	.....	29
9	Skow-aal-hu village, about 90 miles above mouth of Fraser River	.....	.....	70
10	Fort Hope, altitude of Fraser River	.....	.....	120
11	Indian village on Chiloweyuck River, 5 miles above Chiloweyuck Depot	49 07.8	121 55.0	77
12	Foot of first high ridge after leaving Chiloweyuck Depot	06.9	56.2	179
13	Chiloweyuck River, north bank, 14 miles above Chiloweyuck Depot, in flat below mouth of Tummeahai Creek, at foot of first mountain over which trail passes	05.0	51.9	419
14	Chiloweyuck River; Frenchmans Camp, 21 miles above Chiloweyuck Depot	05.1	42.3	723
15	Chiloweyuck River; mouth of Utzetza (second large tributary from the north), 26 miles above Chiloweyuck Depot	06.6	36.8	1,071
16	Chiloweyuck River; Samana village, 24 miles above Chiloweyuck Depot and 2 miles above mouth of Senehsay Creek	05.8	39.3	913
17	Chiloweyuck River; 33 miles above Chiloweyuck Depot and 3 miles below Chiloweyuck Lake	06.0	30.7	1,550
18	Chiloweyuck River, 10 miles above Chiloweyuck Depot	06.0	57.3	157
19	Trail, Chiloweyuck Depot to Chiloweyuck Lake; spring west of summit of first high ridge	05.7	54.4	1,027
20	Trail, Chiloweyuck Depot to Chiloweyuck Lake, summit first ridge	05.5	54.2	1,268
21	Tummeahai Creek, mouth of (25 feet above water), 15 miles above Chiloweyuck Depot	04.4	49.3	400
22	Chiloweyuck Depot (15 feet above mean water), 63 miles from the sea	09.5	58.0	39
23	Camp Tummeahai, 3 miles above mouth of Tummeahai Creek	02.1	47.6	1,146
24	Forks of Tummeahai, 7 miles above mouth of Tummeahai Creek	00.2	43.8	2,056
25	Put-lush-go-hap Lake, on Main Fork Tummeahai Creek, 10 miles above its mouth	48 58.5	41.0	3,639
26	Foot of rapids in Tummeahai Creek, below lake, 9½ miles from creek's mouth	59.2	41.3	2,915
27	Divide between Tummeahai Creek (Main Fork) and Sen-eh-say and Nooksahk, 12 miles above mouth of Tummeahai Creek, 11 miles from mouth of Sen-eh-say Creek, and 5 miles from Nuquoichum, tributary of the Nooksahk	57.4	39.4	6,117
28	Tummeahai Creek (head of South Fork), 11 miles above mouth of Tummeahai Creek	57.8	44.9	3,745
29	Divide between Nooksahk and Tummeahai (South Fork), 11½ miles above mouth of Tummeahai Creek and 14 miles above Cowap, tributary of the Nooksahk	57.4	44.8	5,893

Elevations along the forty-ninth parallel, etc.—Continued.

No.	Station.	Latitude.	Longitude.	Elevation.
		° ′	° ′	*Feet.*
30	La-yome-sin Creek, crossing about ¼ mile above mouth, 11 miles above Chiloweyuck Depot	49 04.3	121 54.0	572
31	La-yome-sin Creek, 4 miles above mouth	02.8	52.9	1,026
32	Summit, east head of La-yome-sin and Nooksahk, 8 miles above mouth of La-yome-sin	00.0	49.4	5,212
33	Summit of mountain in divide between La-yome-sin and Tummeahai, near junction of this ridge with the Chiloweyuck-Nooksahk divide	00.4	49.6	4,930
34	Chiloweyuck-Nooksahk divide, highest point in this immediate vicinity	48 59.2	53.0	5,200
35	Summit Kaisootst Mountain	57.8	57.0	5,289
36	Summit Signal peak	59.2	122 00.1	4,991
37	Summit Tummeahai	49 01.9	121 45.1	6,633
38	Divide between Nooksahk and Tummeahai	48 57.3	43.5	5,893
39	Summit La-yome-sin Mountain	49 01.9	50.5	5,884
40	Summit Klehtlakeh Mountain	11.0	40.0	6,840
41	Near summit Put-lush-go-hap Mountain	48 59.7	38.8	a 7,195
42	Summit Put-lush-go-hap Mountain	59.7	38.8	7,687
43	Sen-eh-say Creek, mouth of, 22 miles above Chiloweyuck Depot	49 04.0	40.8	823
44	Sen-eh-say Creek, 5 miles from mouth, at mouth of Chuchum Creek	02.0	38.0	1,621
45	Sen-eh-say Creek, 8 miles from mouth, at forks	48 59.8	36.7	2,394
46	Sen-eh-say Creek, 11 miles from mouth, at head of West Fork	57.7	39.4	3,302
47	En-saaw-kwatch Creek, mouth of, 29 miles above Chiloweyuck Depot	49 05.5	34.7	1,296
48	En-saaw-kwatch Creek, 4 miles above its mouth	02.2	32.7	2,900
49	En-saaw-kwatch Creek, heads of, 10 miles above its mouth	48 58.5	29.4	5,073
50	Divide between two western tributaries of Klab-neh Creek, 4½ miles from mouth of tributaries	57.4	28.3	5,617
51	High point on same divide; En-saaw-kwatch and Klab-neh	57.0	28.4	6,856
52	First western tributary of Klab-neh Creek, 4 miles above its mouth	58.2	27.3	4,317
53	First western tributary of Klab-neh Creek, mouth of, 2 miles above mouth of Klab-neh and 42½ miles above Chiloweyuck Depot	59.6	23.5	2,076
54	Camp Chiloweyuck on Klab-neh Creek, 1 mile above Lake Depot	49 00.4	23.7	2,002
55	Lake Depot on Chiloweyuck Lake (6 feet above lake level, approximately)	01.8	23.0	1,997
56	Peak west of Chiloweyuck Lake	02.2	26.6	7,244
57	Pekosie Lake, 4 miles above mouth of Pekosie Creek	48 58.9	122 02.8	790
58	Nooksahk River, 46 miles above mouth, and 4 miles above mouth of Pekosie Creek	55.6	02.5	635
59	Nooksahk River, 50 miles above mouth, at mouth of Cowap Creek	53.7	121 57.0	701
60	Nooksahk River, 53 miles above mouth, near mouth of Noochsakatsu, South Branch	53.3	55.1	b 936
61	Nooksahk River, 56 miles above mouth, near mouth of Tchahko, South Branch	53.2	52.0	1,299
62	Nooksahk River, 62 miles above mouth, right bank.	53.9	44.7	1,307
63	Nooksahk River, 66 miles above mouth, right bank, at mouth of Nuquoichum	54.1	40.3	2,044
64	Head of Nuquoichum, 4½ miles from mouth	57.8	38.0	5,451

a "Summit perhaps 300 feet higher." H. Custer, 1863.

b Observations taken on the trail and "should not perhaps be taken as the height of the river."

Elevations along the forty-ninth parallel, etc.—Continued.

No.	Station.	Latitude.	Longitude.	Elevation.
		° ′	° ′	*Feet.*
65	Limit of growth of timber, Put-lush-go-hap Mountain	49 00.0	121 39.0	6,593
66	.....do	48 57.5	37.5	6,117
67	Kockolum Creek, half mile above mouth (mouth is half mile below Chiloweyuck)	49 05.7	26.2	1,973
68	Kockolum Creek, 3 miles above mouth, outlet of first lake (Kehkawalum)	07.2	25.6	2,652
69	Kockolum Creek, 4½ miles above mouth, between two lakes	08.8	24.8	2,843
70	Kockolum Creek, 5½ miles above mouth, divide from Klehkwunnum; near head of Indian Lake and 4 miles from mouth of this tributary of Klehkwunnum	09.5	24.3	3,259
71	Water of second lake, 16 miles from mouth of Klehkwunnum *a*	09.6	24.4	3,132
72	Klehkwunnum Creek, mouth of Pips Creek	12.3	21.4	1,917
73	Klehkwunnum Creek, 19 miles from mouth, marsh lakes near head of	10.0	18.0	1,927
74	Divide between Skagit and Fraser rivers, head of Kle-sil-kwu Creek *b*	09.3	16.8	1,948
75	Junction of Man-sel-pan-ik and Kle-sil-kwu creeks.	07.8	13.6	1,820
76	Junction of Man-sel-pan-ik and Kle-sil-kwu creeks, 4½ miles above mouth of Kle-sil-kwu	08.0	13.0	1,860
77	High mountain, northeast side of Klehkwunnum.	10.6	14.5	6,480
78	Skagit Ford, 110 miles from mouth of Skagit River.	07.7	08.5	1,752
79	Man-sel-pan-ik Creek, 4 miles from junction with Kle-sil-kwu Creek	04.6	14.5	3,027
80	Man-sel-pan-ik Creek, 7 miles from junction with Kle-sil-kwu Creek	02.4	14.3	3,491
81	Man-sel-pan-ik Creek, 7½ miles from junction with Kle-sil-kwu Creek, first western tributary	01.6	14.4	3,550
82	Man-sel-pan-ik Creek, 8 miles from junction with Kle-sil-kwu Creek, where Whatcom trail strikes it	01.2	14.4	4,080
83	Man-sel-pan-ik and Skagit divide, second summit on Whatcom trail	01.9	13.4	5,718
84	Summit on trail, Chuch-che-hum to Skagit, 9 miles from mouth of Man-sel-pan-ik; 7 miles from mouth of Chuch-che-hum	00.6	15.3	4,505
85	Lowest point of same divide	00.5	15.3	4,445
86	Head of gorge 150 yards west of divide	00.4	15.1	4,143
87	Summit of old Whatcom trail	00.9	16.3	5,664
88	Blue Lake, 6 miles from mouth of Chuch-che-hum Creek	00.4	15.6	3,725
89	Divide, Chiloweyuck-Skagit-Fraser	02.3	16.3	6,837
90	Camp Chuch-che-hum, 5½ miles from mouth of Chuch-che-hum Creek	00.1	16.7	3,420
91	Nef Prairie, 3 miles southeast of Lake Depot	00.2	20.2	2,592
92	Klab-neh Creek, 4 miles from mouth	48 58.0	22.6	2,078
93	Klab-neh Creek, 5 miles from mouth, first tributary from the east	57.2	23.1	2,090
94	Klab-neh Creek, 7 miles from mouth, near second large tributary from the east	55.8	23.3	2,243
95	Klab-neh Creek, 9½ miles from mouth, near third large tributary from the east	54.3	25.2	2,414
96	Klab-neh Creek, 10 miles from mouth	54.0	25.6	2,538
97	Near summit of ridge west of Klab-neh	54.0	26.9	4,410

a This is supposed to be the lowest of all the divides between these two streams, 20 miles from mouth of Klehkwunnum Creek and 7 miles from mouth of Kle-sil-kwu Creek.

b This stream is supposed to fall gently till near its entrance into Fraser River, 2 miles below Fort Hope, where it becomes rapid.

Elevations along the forty-ninth parallel, etc.—Continued.

No.	Station.	Latitude.	Longitude.	Elevation.
		° ′	° ′	*Feet.*
98	Summit of Goat Mountain; divide between Klab-neh and Zakeno (tributary of the Skagit), 30 miles above mouth of Zakeno, 50 miles above mouth of Skagit, and 16 miles from mouth of Klab-neh	48 51.7	121 24.0	5,862
99	On divide Klaheh Creek, a branch of Red Mountain Creek, 4 miles above mouth of latter	52.0	24.2	5,106
100	Red Mountain Creek	52.6	23.1	2,932
101	Red Mountain Creek, 4½ miles above mouth, near head of southern branch	50.9	21.4	3,754
102	Divide Klab-neh and Glacier creeks, 8½ miles above mouth of Red Mountain Creek, 15 miles above mouth of Glacier Creek	52.0	17.6	5,107
103	Glacier Creek (Sko-mel-pua-nook), head or first forks of, 13½ miles above its mouth	52.0	15.4	2,891
104	Glacier Creek, 11 miles above its mouth	52.9	13.4	2,550
105	Glacier Creek, 9 miles above its mouth	53.3	11.2	2,292
106	Glacier Creek, 5 miles above its mouth	54.4	08.0	2,075
107	Glacier Creek, 2½ miles above its mouth	54.4	04.7	1,940
108	Glacier Creek, mouth of, junction with Skagit, 84 miles from mouth of Skagit	55.0	02.4	1,525
109	Skagit River, 87 miles above its mouth	57.2	03.4	1,531
110	Skagit River, 82 miles above its mouth	53.5	01.2	1,468
111	Skagit River, 71 miles above its mouth	48.6	01.6	1,405
112	Skagit River, 64 miles above its mouth	44.2	02.0	1,298
113	Camp Skagit, 96 miles above mouth of Skagit (15 feet above river)	49 00.0	02.8	1,573
114	Skagit Cache, in Skagit Valley, 2 miles east of river	02.2	01.2	1,748
115	Camp on tributary of Skagit, ¼ mile above mouth; its mouth 97 miles above Skagit's mouth	01.5	02.0	1,586
116	Camp on tributary of Skagit (Ne-pó-pe-eh-kum), 1 mile above mouth; its mouth 99 miles above Skagit's mouth	02.6	03.1	1,611
117	Camp on Skagit (15 feet above water), 100 miles above Skagit's mouth	02.9	04.0	1,624
118	Camp on Skagit (25 feet above water), 101 miles above Skagit's mouth	03.6	04.3	1,637
119	Camp on slough of Skagit, 104 miles above Skagit's mouth	04.7	05.0	1,675
120	Camp on Skagit (20 feet above water), 108 miles above Skagit's mouth	06.7	07.2	1,727
121	Skagit River, 115 miles above its mouth	11.0	02.6	1,812
122	Skagit River, 120 miles above its mouth, above mouth of Kullas Creek	14.1	03.0	1,947
123	High point on divide, Skagit-Similkameen	18.3	120 56.8	6,871
124	Camp near Skagit-Similkameen divide, 126 miles from mouth of the Skagit	17.8	58.1	5,254
125	Near head of large tributary to the Skagit, 9 miles from its entrance into the Skagit, at which point the elevation is about 1,980 feet, the point being 122 miles above its mouth	16.3	52.1	2,969
126	Summit of pass between Skagit and Similkameen, 126 miles from mouth of Skagit	17.9	59.0	5,668
127	Lake, head of Similkameen, 125 miles from mouth of Similkameen	18.3	57.5	5,307
128	Camp, first forks, *a* 122 miles from mouth of Similkameen	21.6	53.7	4,163
129	On divide, crossing a great bend of the Similkameen	23.2	52.0	5,074
130	Fort Hope trail, 1 mile east of junction with Whatcom, near two small lakes	25.3	52.5	5,947
131	High point on trail	25.0	51.9	5,490

a Whatcom trail leaves river.

Elevations along the forty-ninth parallel, etc.—Continued.

No.	Station.	Latitude.	Longitude.	Elevation.
		° ′	° ′	*Feet.*
132	Forks—trails to Whatcom and to Fort Hope	49 25.8	120 51.1	5,722
133	Fort Hope trail, upper crossing of Similkameen, 120 miles above its mouth	23.8	54.5	4,028
134	Fort Hope trail, 6 miles west of Similkameen crossing and 6 miles from mouth of creek up which the trail runs	21.2	121 00.8	4,436
135	Summit of ridge, left bank of Similkameen, near upper crossing	23.7	120 55.3	4,750
136	Fort Hope trail, summit between two crossings of Similkameen	25.3	52.4	5,965
137	Camp on Fort Hope trail	29.4	47.5	4,906
138	On ridge south of valley of Similkameen	30.4	47.1	4,559
139	Encampement des Femmes, junction of trails to Forts Hope and Kamloops, 104 miles above mouth of Similkameen	31.5	45.2	2,506
140	Summit of ridge north of Encampement des Femmes	34.5	42.8	4,921
141	Summit of ridge on trail	27.2	35.5	4,085
142	Camp on creek 1 mile east of last summit, 1¼ miles above mouth of creek, which is 90 miles above mouth of Similkameen	27.3	34.4	4,035
143	Camp on Similkameen 82 miles above its mouth and one-half mile below mouth of Pa-say-ten Creek	27.0	23.9	2,069
144	Summit of ridge on south side of Similkameen	21.6	24.5	4,041
145	Base of same ridge, crossing of Yakl-keh-whel-lich-ler (?), 11 miles above its mouth, which is 72 miles above mouth of Similkameen	21.5	23.9	2,580
146	Yan-set-ah-skwa Creek, 5 miles above its mouth, which is 81 miles above mouth of Similkameen.	31.2	24.9	2,379
147	Camp on Similkameen 64 miles above its mouth and 6 miles below Skai-shin Creek	21.3	05.2	1,919
148	Camp on Similkameen 52 miles above its mouth and 3 miles above mouth of Nais-nu-loh	14.5	119 59.9	1,477
149	Similkameen River, 49 miles above its mouth and just below mouth of Nais-nu-loh	13.1	56.8	1,455
150	Camp on Similkameen 36 miles above its mouth, in brushy bottom	09.5	43.8	1,406
151	Camp on northeast tributary of Similkameen 2 miles above mouth, the mouth 38 miles above mouth of Similkameen	11.7	42.5	2,248
152	Camp in flat near river, one-half mile above mouth of large creek coming from west, its mouth 31 miles above mouth of Similkameen	05.2	43.0	1,356
153	Camp on side of mountains, one-half mile north of creek coming from southwest, its mouth 26 miles from mouth of Similkameen	01.8	41.1	1,652
154	Summit of ridge bordering Similkameen River on west side	03.0	43.0	5,068
155	Camp Similkameen, 12 miles above mouth of Similkameen	48 59.2	34.9	1,164
156	Camp on Similkameen 1¼ miles above mouth of Similkameen	55.5	25.0	904
157	Camp on Okinakane 11 miles below forks, 61 miles above mouth of Okinakane; 567 miles above mouth of Columbia	46.0	22.6	955
158	Lake Osoyoos, foot of (4 feet above water), 76 miles above mouth of Okinakane	57.0	24.2	957
159	Lake Osoyoos, camp on east side, 82 miles above mouth of Okinakane	49 02.4	25.0	953
160	Lake Osoyoos, north end of (inlet), 86 miles above mouth of Okinakane	04.5	29.2	931
161	Height of second plateau at foot of hills	13.1	32.3	1,633
162	.....do	05.9	28.9	1,430

Elevations along the forty-ninth parallel, etc.—Continued.

No.	Station.	Latitude.	Longitude.	Elevation.
		° ′	° ′	*Feet.*
163	Summit of ridge, 3 miles east of Okin-á-kane River.	49 07.3	119 27.8	3,027
164	Summit of trail, Similkameen to Okinakane	11.4	39.0	4,251
165	Lake Haipwil (2¼ miles long by three-fourths mile wide)	48 51.0	37.0	1,120
166	Summit of mountain, north of lake	55.6	36.8	4,565
167	Camp on Haipwil Creek 3 miles above forks and 12 miles above its mouth	47.0	37.9	1,376
168	Camp on Haipwil Creek one-half mile above forks and 9 miles above its mouth	48.9	38.0	1,366
169	On Haipwil where it enters couleé, 20 miles above its mouth	40.8	39.1	1,643
170	Divide between Haipwil and Okinakane, near two lakes	48.5	35.4	1,701
171	Summit of hill, Okinakane Valley	45.1	23.6	2,487
172	Camp on Haipwil (West Fork) 8 miles above forks and 17 miles above mouth of Haipwil	47.5	48.7	4,599
173	Summit of trail between a tributary of Che-wach (branch of Haipwil) and [Lake?] Methow, 20 miles from mouth of Haipwil and 5 miles from mouth of Che-wach	46.2	52.0	6,854
174	West foot of ascent to summit	45.9	52.6	6,220
175	On Che-wach at forks, 67 miles above mouth of Methow and 559 miles above mouth of Columbia.	47.8	57.5	3,296
176	Near mouth of tributary of west fork of Haipwil, 9 miles from forks of Haipwil	47.9	49.7	4,627
177	Large lake southwest of mouth of Similkameen, south end, 8 miles from Okinakane River	50.9	29.0	1,819
178	Smaller lake southwest of mouth of Similkameen, east side, 2 miles from Okinakane River	53.0	27.5	1,766
179	Summit of trail, Skagit to Pasayten	49 02.3	120 57.4	5,900
180	Saddle Divide, waters Skagit and Pasayten, 10 miles from mouth of Ne-po-pe-eh-kum Creek, which is 100 miles above mouth of Skagit and 24 miles from mouth of N'-shitl-shutl River	02.1	57.1	5,281
181	Summit Cache	01.9	56.5	5,594
182	First depression east of Summit Cache	02.0	55.3	5,570
183	Third high point east of Summit Cache	02.3	53.7	5,819
184	Summit to north of trail *a*	02.5	54.6	6,221
185	Summit near end of ridge	03.0	50.0	6,233
186	First water below ridge on trail, 15 miles above mouth of N'-shitl-shutl, which is at Pasayten Cache	03.2	48.6	3,860
187	Camp on N'-shitl-shutl 10½ miles above its mouth, at mouth of Chu-chu-wun-ten	03.5	42.9	3,431
188	Pasayten Cache, at mouth of N'-shitl-shutl, 24 miles above mouth of Pasayten, which is 82 miles above mouth of Similkameen	09.6	33.6	3,194
189	Camp Pasayten, 36 miles from mouth of Pasayten.	48 59.7	32.2	3,676
190	First knoll on mountain east of Pasayten Cache	49 08.7	32.0	4,880
191	Top of rocky slide near which trail passes on same mountain	07.5	29.5	6,456
192	Camp on west slope of mountain	08.7	31.3	4,777
193	Elevation east of hill	08.6	30.8	5,157
194	Camp	07.5	28.3	4,701
195	Western principal summit	07.5	25.5	6,433
196	Eastern principal summit	07.8	23.5	6,455
197	Camp east and above tributary of Nais-nu-loh	08.2	22.2	6,494
198	Elevation 1¼ miles east of above	08.3	21.6	6,170

a To the north of this trail, in latitude 49° 03.7′, longitude 120° 53.5′, is another divide, between Ne-po-pe-eh-kum and N'-shitl-shutl, which is about 4,500 feet high. It is 11 miles from mouth of N'-shitl-shutl.

Elevations along the forty-ninth parallel, etc.—Continued.

No.	Station.	Latitude.	Longitude.	Elevation.
		° ′	° ′	*Feet.*
199	Camp on Nais-nu-loh, 18 miles above its mouth	49 08.8	120 15.1	3,568
200	Camp Nais-nu-loh Cache, 21 miles above mouth of Nais-nu-loh	07.2	17.3	3,678
201	Saddle between two principal summits, 26 miles above mouth of Nais-nu-loh	07.5	24.2	6,005
202	Camp on Nais-nu-loh, 7 miles above its mouth, at bend, mouth of creek	07.8	00.5	2,525
203	Camp on Nais-nu-loh, 5¼ miles above its mouth, at trail crossing	09.1	00.2	2,171
204	On Nais-nu-loh, ¼ mile above its mouth, where trail leaves it	13.1	119 57.4	1,515
205	Camp on southeastern tributary of Lake Osoyoos, 6 miles from its mouth, last trail crossing	48 59.5	16.4	3,092
206	Summit of trail, Lake Osoyoos to Ne-hoi-al-pit-kwu River	49 00.6	11.8	4,068
207	Highest terrace east of summit	01.1	09.3	3,476
208	Fourth terrace east of summit, just before descending to valley of Rock Creek	02.6	05.4	3,032
209	First crossing of Rock Creek, 6 miles above its mouth	02.7	05.2	2,762
210	Fourth terrace, just after ascending from valley of Rock Creek	02.8	04.9	3,101
211	Upper terrace above town [? Twai-yeep] on Rock Creek, just before descending to Ne-hoi-al-pit-kwu River	03.2	118 59.0	2,366
212	Upper camp on Ne-hoi-al-pit-kwu, 80 miles above its mouth, at mouth of Rock Creek	03.2	58.7	2,153
213	Camp Ne-hoi-al-pit-kwu, 66 miles above its mouth (20 feet above water)	48 59.1	44.5	1,826
214	On Ne-hoi-al-pit-kwu River, 44 miles above its mouth	49 00.4	28.4	1,663
215	Camp Statapoostin, 36 miles above its mouth	00.2	16.3	1,636
216	En-châhm Lake, outlet of, 1¼ miles from Ne-hoi-al-pit-kwu River, at a point 32 miles from its mouth.	02.1	12.7	1,531
217	Camp on Ne-hoi-al-pit-kwu, 29 miles from its mouth	48 59.4	12.5	1,468
218	Camp on Ne-hoi-al-pit-kwu, 16 miles from its mouth	50.5	10.4	1,466
219	Camp on Ne-hoi-al-pit-kwu, 9 miles from its mouth.	46.3	06.8	1,226
220	Camp on Ne-hoi-al-pit-kwu, 1 mile from its mouth.	40.9	06.5	1,271
221	Camp on Ne-hoi-al-pit-kwu, at mouth, 746 miles from mouth of Columbia	40.0	06.2	1,252
222	Columbia River crossing, 1 mile below Kettle Falls (20 or 25 feet high), 782 *a* miles above its mouth.	36.8	07.5	1,202
223	Columbia River camp (25 feet above river), 766 miles above its mouth	51.6	117 53.9	1,341
224	Camp Columbia (58 feet above water now nearly at lowest stage), 783 miles above its mouth	59.8	37.7	1,317
225	Camp Columbia (another measure)			1,514
226	Camp on summit on trail westward from Camp Columbia	58.6	45.4	3,410
227	Camp on tributary of Yóme-tsin, 4 miles from Yóme-tsin's mouth, which is 775 miles from mouth of Columbia	58.1	48.1	2,166
228	High point on trail	58.9	49.5	4,650
229	Camp	58.0	58.7	2,684
230	Summit on trail, divide between Yome-tsin and Ne-hoi-al-pit-kwu	57.7	118 02.9	4,739
231	Camp on tributary of Ne-hoi-al-pit-kwu, 5 miles above its mouth, which is 28 miles above mouth of Ne-hoi-al-pit-kwu	57.2	07.0	3,363

a Apparently an error for 742.

Elevations along the forty-ninth parallel, etc.—Continued.

No.	Station.	Latitude.	Longitude.	Elevation.
		° ′	° ′	*Feet.*
232	High point on trail east of divide	48 57.8	118 02.0	4,707
233	Crossing Creek, 3 miles east of camp—first plateau, 2 miles above mouth of creek, which is 59 miles above mouth of Okinakane	43.7	119 19.2	1,383
234	Crossing Creek, 5 miles east of camp—second plateau, 6 miles above mouth of Kwahaloose Creek, which is 57 miles above mouth of Okinakane River	42.1	15.2	2,158
235	Divide between Kwahaloose Creek and large eastern tributary [Lower Bonaparte of Arrowsmith's map] of Okinakane River	40.6	13.7	3,350
236	Camp on first large branch of Lower Bonaparte River, 3 miles above mouth of branch and 12 miles above mouth of river	39.6	08.2	2,563
237	Divide between 2 branches of Lower Bonaparte River and a southern tributary of the Ne-hoi-al-pit-kwu River; 11 miles above mouth of first branch, which is 12 miles above mouth of second branch, which is 33 miles above mouth of Lower Bonaparte River and 22 miles from mouth of southern tributary of Ne-hoi-al-pit-kwu River, which is 63 miles above mouth of that river	41.3	118 58.3	4,312
238	Camp on second branch of Lower Bonaparte River, 9 miles above its mouth	40.7	54.7	3,531
239	Camp on second branch of Lower Bonaparte River, 3 miles above its mouth	38.7	47.8	2,459
240	Summit of ridge north of No. 238=average height of mountains in vicinity	41.0	56.6	5,220
241	Crossing of Lower Bonaparte, 38 miles above its mouth	38.7	39.9	2,746
242	Divide between Okinakane and Columbia, 45 miles from mouth of Lower Bonaparte and 19 miles from the Columbia, at a point 739 miles from its mouth	37.9	32.3	5,662
243	High point north of trail on divide between Okinakane and Columbia	39.2	33.1	7,035
244	Camp No. 3, on Columbia River *a*	48 37.0	118 06.9	1,207
245	Camp No. 2, on Columbia River	.....	.....	1,622
246	Summit of ridge bordering Colville Valley to north	.....	.....	3,017
247	Camp No. 1, on Peptashin Creek near mouth	.....	.....	1,535
248	Summit of ridge=average height of ridges in vicinity	.....	.....	3,718
249	Camp No. 15, Peptashin Creek near town	.....	.....	1,957
250	Colville depot, at observatory	.....	.....	1,963
251	Camp No. 1, Mill Creek near Colville depot	.....	.....	1,653
252	Lake 5 miles southeast of Colville depot	.....	.....	2,153
253	Summit of mountain west of Colville depot	.....	.....	3,330
254	Summit of mountain 6 miles east of Colville depot	.....	.....	5,697
255	Camp No. 2 on Mill Creek near Stugar's farm	.....	.....	1,629
256	Mountain east of Camp No. 2	.....	.....	4,880
257	Mountain south, on same ridge, and north of Francois' house	.....	.....	4,096
258	Camp No. 3, near Francois' farm	.....	.....	1,717
259	Mountain southwest of Francois', near trail	.....	.....	3,186
260	On branch of Mill Creek, at crossing of trail, 5 miles south of Francois', An-i-aht-wa or Oit-chin Prairie	.....	.....	1,765
261	Crossing of first stream south of Hughes ranch on wagon road	.....	.....	1,734
262	On wagon road between Colville and Spokane at small ponds	.....	.....	2,119
263	On head of small lake, east end, near wagon road	.....	.....	1,970

a Second cahier begins here.

Elevations along the forty-ninth parallel, etc.—Continued.

No.	Station.	Latitude.	Longitude.	Elevation.
		° ′	° ′	*Feet.*
264	Highest point on Colville wagon road			4,033
265	Chemakane bridge, junction of trail and wagon road			1,922
266	Summit of trail between Mill Creek and Little Spokane			2,735
267	Walker's Prairie, on small branch of Chemakane			1,897
268	Mouth of Chemakane—approximate			1,366
269	Summit of trail, short cut between Chemakane and Spokane			2,809
270	Trail at northernmost bend of Spokane River, 13 miles below mouth of Little Spokane *a*			1,500
271	On plateau above Spokane River, 7 miles below mouth of Little Spokane			1,854
272	On edge of Spokane River, 7 miles below mouth of Little Spokane			1,558
273	Little Spokane, mouth of, at water's edge			1,635
274	Summit of hill, northeast of mouth of Little Spokane			3,140
275	On little Spokane, near crossing of trail			1,609
276	On plateau south of crossing			1,760
277	On plateau of Spokane River			1,878
278	Hill in bend of Little Spokane, about 5 miles from mouth			2,355
279	On edge of plateau south of trail			2,266
280	On Spokane River, water's edge, near Plant's			1,901
281	On plateau north of Plant's			2,375
282	Plant's house			2,08
283	Trail to Sinyakwateen, 11 miles from Plant's			2,228
284	Trail on Spokane, 3¼ miles below lake [Cœur d' Alene]			2,135
285	Cœur d'Alene Lake			2,151
286	Hill near lake, south of trail			2,499
287	On small lake north of Cœur d'Alene Lake			2,205
288	On summit of spur bordering lake			2,862
289	Average height of rolling country north and northeast of lake			3,170
290	Plateau north and east of trail to Mission			2,767
291	Creek 3¼ miles east of arm of lake [Cœur d'Alene]			2,121
292	Plateau north of creek crossing			2,681
293	Shore of large lake south of Checolsum Mountain			2,262
294	Point on mountain spur between lakes			3,577
295	Trail to Sinyakwateen, 19 miles from Plant's			2,200
296	Little knoll 5 miles beyond and west of road			2,835
297	Tesemmeus lakes, [? Tesimini]			2,322
298	On edge of plateau 3 miles east of road			2,540
299	Top of plateau on road 4 miles south of Pekowla Lake			2,539
300	Bottom of plateau			2,333
301	On Pekowla Lake			2,200
302	Sinyakwateen depot, right bank of Clark Fork of the Columbia River			2,084
303	Vermilion Creek, mouth of fall of Clark Fork from [Pend Oreille] lake to falls about 0.44 foot per mile; falls about 5 feet			2,074
304	Checolsum Mountain			5,706
305	Crossing of trail near forks of creek north of Checolsum Mountain			2,455

a From the northernmost bend to mouth of Spokane the average fall is about 9 feet per mile.

Elevations along the forty-ninth parallel, etc.—Continued.

No.	Station.	Latitude.	Longitude.	Elevation.
		° ′	° ′	*Feet.*
306	Crossing of tributary of Little Spokane. Little Spokane has an average fall of about 15 feet per mile			1,880
307	Lake on Little Spokane			1,947
308	Trail north of lake			2,098
309	On plateau above Little Spokane			? 2,441
310	On high plateau on trail			2,358
311	Lake at head of Little Spokane			2,237
312	Trail between Spokane and Clark Fork Divide			2,335
313	Clark Fork at outlet of Pend Oreille Bay			1,942
314	Clark Fork 8 miles below falls			2,024
315	Clark Fork 4 miles above Mission			1,937
316	Clark Fork at mouth of Skomin Creek			1,926
317	St. Ignatius Mission			1,894
318	Skomin Creek, 5 miles above mouth			2,769
319	Skomin Creek, 9 miles above mouth			2,901
320	Skomin Creek, 11 miles above mouth			3,736
321	Divide between Skomin and Chelonscan creeks			4,199
322	Mountain 1½ miles south of divide			5,218
323	2 miles below divide on eastern slope			3,438
324	Trail from Mission to Kaniksu Lake, 7 miles			3,041
325	Crossing of creek, 12 miles from Mission			3,585
326	Trail above and beyond crossing of creek			3,640
327	Teh-kwat Mountain, north of trail			5,770
328	Water on Teh-kwat Mountain, south of trail			5,443
329	Crossing of first creek east of divide			2,740
330	Creek 5 miles west of lake			2,606
331	Kaniksu Lake			*a* 2,443
332	Upper Kaniksu Lake			*a* 2,435
333	On creek, 2 miles above Upper Lake			2,469
334	Long bridge on trail from Sinyakwateen to Chelemta, 6 miles			2,086
335	Clark Fork, 14 miles above Sinyakwateen			2,089
336	Kalispelm Lake			2,095
337	Pack River crossing			2,101
338	Divide between Pack and Kootenay rivers			2,138
339	Small lake west of trail and north of divide			2,090
340	Trail in forks of creek			2,064
341	Chelemta depot			1,796
342	Kootenay River, 18 miles below Chelemta			1,802
343	Crossing of Acklew Creek			2,248
344	Acklew Cache			2,304
345	Camp Kootenay West (about 50 feet above water)			1,823
346	Mountain N. 42° E. from Camp Kootenay West			5,573
347	Trail from Chelemta to Acklew, 8 miles, first water			2,695
348	Trail from Chelemta to Acklew—10½ miles			2,694
349	Trail from Chelemta to Acklew—14 miles—crossing of stream			2,557
350	Trail from Chelemta to Acklew—17 miles—grassy mound			2,548
351	Trail from Acklew to Mooyie—1 mile—divide on trail			3,260
352	Trail from Acklew to Mooyie—3 miles—divide			2,985

a The contradiction here by which the upper lake level is less than the lower one is noted in the original MS., but not corrected.

Elevations along the forty-ninth parallel, etc.—Continued.

No.	Station.	Latitude.	Longitude.	Elevation.
		° ′	° ′	*Feet.*
353	Trail from Acklew to Mooyie—3½ miles—head of Ar-ka-klu-ne *a* Creek			2,882
354	Trail from Acklew to Mooyie—8 miles—prairie			2,638
355	Trail from Acklew to Mooyie—13 miles—creek crossing			2,798
356	Trail from Acklew to Mooyie—terrace south of crossing			2,811
357	Trail from Acklew to Mooyie—lower crossing of Ar-ka-klu-ne			2,678
358	Trail from Acklew to Mooyie—terrace above			2,756
359	Trail from Acklew to Mooyie—crossing of Mooyie			2,682
360	Camp Mooyie			2,689
361	Mooyie Cache			2,742
362	Mountain ridge east of Camp Mooyie			6,639
363	Summit of ridge			6,698
364	Same ridge 8 miles south			4,466
365	Crossing of Mooyie 8 miles below Camp Mooyie			2,142
366	Second crossing of Mooyie, from cache (14 feet above water)			2,718
367	Fourth crossing of Mooyie, from cache			2,850
368	Sixth crossing of Mooyie, from cache			2,934
369	7 miles from sixth and 2½ miles from seventh crossing			2,940
370	Seventh crossing at foot of lake (3 feet above water)			3,029
371	Terrace east of seventh crossing—on trail			3,291
372	First stream—2½ miles beyond seventh crossing of Mooyie			3,067
373	Second stream—9½ miles beyond seventh crossing of Mooyie			3,766
374	Third stream—10½ miles beyond seventh crossing of Mooyie			3,514
375	11 miles from seventh crossing, north of lakes			3,136
376	Headwaters of Mooyie, 13½ miles from seventh crossing			3,296
377	Terrace near headwaters of Mooyie			3,383
378	South and near divide between Mooyie and Kootenay			3,544
379	Divide between Mooyie and Kootenay			3,642
380	Joseph's Prairie			2,959
381	Crossing of stream [Akis-ka-klail] south of Joseph's Prairie			3,041
382	Kootenay River northeast of Joseph's Prairie			2,451
383	Crossing of first creek going down the Kootenay *b*			2,682
384	Crossing of second creek going down the Kootenay—10 miles beyond			2,679
385	Crossing of third creek going down the Kootenay			2,619
386	Crossing of fourth creek going down the Kootenay			2,741
387	Creek 9 miles beyond			2,420
388	Prairie on Kootenay—25 miles above Camp Kootenay East			*c* 2,400
389	Prairie on Kootenay—10 miles above Camp Kootenay East			2,364
390	Kootenay River—6 miles above Camp Kootenay East			2,361
391	On creek—5½ miles north of Camp Kootenay East			2,401
392	Camp Kootenay East (30 feet above water)			2,348

a Also written Acaclunah.

b The fall of Kootenay River for about 30 miles south from latitude 49° 35′ N. is 2 feet per mile.

c At bend of Kootenay River above mouth of Elk River computed height is 2,381 feet. The fall of the Kootenay for about 20 miles from above mouth of Elk River south is 4½ feet per mile.

Elevations along the forty-ninth parallel, etc.—Continued.

No.	Station.	Latitude.	Longitude.	Elevation.
		° ′	° ′	*Feet.*
393	Camp Kootenay East—at water			2,318
394	South of Camp Kootenay East (3 feet above water)			2,313
395	Kootenay River 2½ miles below camp (3 feet above water)			2,300
396	Kootenay Cache			2,316
397	First bench above river			2,368
398	Second bench above river			2,566
399	First creek south of Kootenay Cache			2,355
400	Trail on Tobacco Plains, highest point south of cache			2,755
401	Creek 9 miles from cache			2,691
402	Entrance of Akonoho Pass			3,015
403	11 miles from entrance and 3 miles from summit of pass			4,195
404	2½ miles west of summit			4,460
405	One-half mile west of summit			5,138
406	Divide between Kootenay and Flathead rivers			5,218
407	On divide, one-half mile north of pass			6,953
408	On spur of divide, 2 miles north of pass			6,278
409	Divide between Wigwam and Akonoho			5,332
410	Wigwam Station			4,694
411	Small prairie one-half mile east of summit of pass			5,065
412	Four miles east of summit of pass (65 feet above water)			4,731
413	Crossing of stream, 7½ miles east of summit			4,522
414	Prairie, 12 miles east of summit			4,164
415	Large creek down which trail follows (water of Yakinikak creek opposite Prairie)			4,112
416	Flathead valley, upper terrace			4,267
417	Peak west of Flathead			7,373
418	Crossing of Flathead			3,827
419	1½ miles beyond crossing, in Prairie			3,763
420	Camp Kishenehn, 4 miles to mouth of Kishenehn—fall 53 feet per mile			4,184
421	Three miles above Camp Kishenehn (3 feet above water)—fall 63 feet per mile			4,252
422	Prairie, 8 miles above Kishenehn—fall 58 feet per mile			4,541
423	Angle of valley, 12 miles above—fall 36 feet per mile			4,705
424	Angle of valley, 2½ miles above this angle			4,808
425	Open place in burnt timber			5,133
426	Mule camp			5,191
427	Summit of pass, 9 miles from angle, 21 miles from Camp Kishenehn and 25 from mouth of creek			5,846
428	Near outlet of lake east of summit			5,407
429	1½ miles east of summit, on creek			5,378
430	Camp Akamina			6,447
431	On divide north of summit monument			7,986
432	Bluff SE. of Camp Akamina			6,648
433	Summit monument			a 7,490
434	Mountain in divide 1½ miles N. of pass			8,087
435	Mountain in divide 1 mile NE. of last			8,207
436	Mountain in divide one-half mile N. of last			8,313
437	Mountain in divide 2½ miles NE. of last			8,333

a Another value given in the table, and without comment, is 6,548. Can this be an error for 7,548?

Elevations along the forty-ninth parallel, etc.—Continued.

No.	Station.	Latitude.	Longitude.	Elevation.
		° ′	° ′	*Feet.*
438	Summit of Boundary Pass			6,955
439	Mountain, 1¼ miles north of pass			7,861
440	Kishenehn Mountain			a 8,487
441	Mountain up pass and to the north			a 7,409
442	Kishnenehna Mountain, north and west peak			a 7,937
443	Kishnenehna Mountain, center peak			a 8,170
444	Kishnenehna Mountain, south and east peak			a 9,137
445	Divide 2 miles east of Camp Kishenehn			5,541
446	In valley of creek west of camp and north of boundary			5,119
447	Boundary Mountain, highest peak			8,574
448	Southwest point of ridge of Boundary Mountain			7,260
449	Kootenay River, 3 miles below parallel			2,303
450	Kootenay River, 17 miles below parallel			2,256
451	Kootenay River, 33½ miles below parallel			2,204
452	Kootenay River, 39 miles below parallel			2,184
453	Kootenay River, 50 miles below parallel at crossing of trail			2,148
454	Kootenay River, 13 miles below crossing (8 feet above water)			2,057
455	Kootenay River, 25 miles below crossing; below falls, at high-water mark			1,967
456	Kootenay River, 39 miles below crossing; mouth of the Yahk			1,934
457	Kootenay River, 44 miles below crossing; terrace above river			2,298
458	Forage cache on trail 13 miles from Yahk			2,161
459	Camp on terrace on trail 3 miles east of Mooyie Crossing			2,260
460	Kootenay River, 55 miles below crossing; mouth of Mooyie			1,792
461	Kootenay River, 61 miles below crossing; Chelemta depot (9½ feet above high water)			1,796
462	Summit of mountain range between waters of Wigwam River and Skits-ooh-nau-na Creek			7,852
463	Camp in forks of tributary of Tobacco River			3,256
464	Camp on west side of Kootenay Valley			2,942
465	Camp on waters of Kootenay, near divide with Yahk			4,862
466	Summit of divide between Yahk and Kootenay			5,498
467	Camp west of divide			5,520
468	.....do			4,954
469	Camp on mountain, tributary of Yahk			4,794
470	Camp on east fork of Yahk			3,483
471	Camp in forks of Yahk			3,194
472	Camp at east bend of Yahk			2,983
473	Camp on Yahk			2,959
474	Camp at west bend of Yahk			2,935
475	Camp on Yahk			2,759
476	.....do			2,697
477	Camp below falls			2,414
478	Camp at mouth of Yahk			1,926

a Measured with theodolite.

INDIAN NAMES.

In the prosecution of the survey considerable attention was given to the language of the native tribes along the line. George Gibbs, who accompanied the party, is referred to in various capacities as geologist, ethnologist, guide, interpreter, and naturalist. The first Chinook dictionary is said to have been prepared by him, and this was to form a part of the final report of the survey. Later Mr. Gibbs was engaged by the Smithsonian Institution in elaborating linguistic material from the tribes of the Northwest. This work was unfinished at the time of his death in April, 1873. Some of it has been published since. To secure uniformity in the spelling of the names of various camps and stations Mr. Gibbs prepared lists which were submitted to General Parke and made official. There are three such lists among the papers. The first two are signed; the third is not signed. The first list is as follows:

Adopted spelling of the names of camps, etc.

[Official: John G. Parke, chief astronomer and surveyor.]

Chiloweyuck.
Chuch-che-hum.
En-saaw-kwatch.
Fraser.
La-yome-sin.
Nooksahk.
Okinakane.
Pehosie.
Semiahmoo.
Sen-eh-say.
Similkameen.
Skagit.
Sumass.
Swehl-tcha.
Tummeahai.

The three lists have been combined, arranged, studied in company with the published maps of the boundary and later official maps. The results are here given with notes derived from such comparison and study. For easy reference on the maps the approximate longitudes are given.

	Approximate longitude.	
	°	′
A-kám-i-na;[1] east fork of Kish-e-nehn Creek	114	10
A-kin-ís-sahtl; Flathead River	114	30
A-kin-kwo-náh-ki;[2] branch of Flathead River heading with Tobacco River	114	30
Ak-káph-kleh; falls of the Kootenay River, Flathead County, Montana	115	45
Ak-o-nó-ho; creek tributary to Tobacco River[3]	115	05
Ak-swák; creek from south at bend of the Kootenay[4]	115	15

[1] Kam-i-na=watershed.
[2] Perhaps this is Yokinikah Creek of the Land Office map of Montana.
[3] Tobacco River=Grave Creek of Land Office map of Montana.
[4] Not named on boundary map; apparently Fisher Creek of Land Office map of Montana, and *Masula* River of official map of British Columbia, 1895.

	Approximate longitude.	
	°	′
Ak-tlak-a; creek above Kish-e-nehn, tributary to Flathead River. Not named on boundary map	114	25
A-kwote-kátl-nam; Chief Mountain or Waterton Lake, upper part across boundary	114	
An-i-áht-wha; Kamass Prairie		
Che-chéet-hu; Skagit cache	121	05
Chelemta (also written Cholemta); cache or depot. Not shown on map or identified. (See Swoots-kóse and Yah-kwoo-káh-keh)	116	20
Che-loús-kan; Little Pend Oreille	116	40
Chém-a-kane; bridge over Walkers Prairie Creek	116	46.4
Chiloweyuck; camp, lake, river, town, etc. Now written Chilliwhack	121	30
Chow-a-wee-la; Fool's Prairie. Not identified.		
Chuk-kóse; the Mooyie Lakes. Not shown on map. In British Columbia, latitude 49° 18′	115	50
Chuch-che-hum; camp and creek tributary to Chiloweyuck Lake	121	15
Chu-chu-wán-ten; creek tributary to N'shitl-shootl River, which is tributary to Pa-say-ten	120	40
En-cháhm;[1] lakes near Statapoostin	118	13
En-kwool-eh-la; mouth of Clark forkof the Columbia. Name not on boundary map	117	37
En-saaw-kwatch;[2] station and creek tributary to the Chiloweyuck	121	30
Háíp-wil;[3] lake near camp Similkameen	119	37
Hó-zo-meen; mountain near camp Skagit	121	
In-chú-in-tum;[4] station and river tributary to the Ne-hoi-alpít-kwu	118	25
Ka-cha-átl; Indian village Aklew (or Acklew) cache	116	22
Kái-seet-lin; crossing of Spokane. Not identified.		
Kais-in; branch of Kat-láh-woke Creek. Not on map and not identified.		
Kal-is-pelm; Pend Oreille Lake in northern Idaho	116	30
Kam-i-na=a watershed.		
Kat-láh-woke; creek running to Flathead [river] through [Boundary] pass; not named on boundary map and not identified. It is near Kísh-e-nehn Creek	114	20
Ka-yak-ka;[5] creek, from south, tributary to Kootenay below falls; large lake on it	115	50
Kin-nook-kleht-nán-na;[6] creek running east from divide [of Rocky Mountains] to [Chief Mountain or Waterton] lake	113	50

[1] Christina Lake of official map of British Columbia, 1895.
[2] Written En-saw-kwatch on boundary map and on above map called Nesquatch.
[3] Harpwil of British Columbia map of 1895 and Blue Lake of Land Office map of Washington.
[4] North fork of Kettle River of British Columbia map of 1895. Also Inishwointon in the manuscript notes.
[5] Lake Creek of Land Office map of Montana.
[6] Kotanie River of official map of British Columbia, 1895.

	Approximate longitude.	
	°	′
Kínt-la; lake and mountains, Flathead County, Montana	114	15
Kísh-e-nehn; camp, creek, and mountain	114	20
Kish-ne-néh-na; mountains	114	15
Kit-lat-laā-nook; creek heading east of Mount Wilson and emptying into lower [Chief Mountain or Waterton] lake	113	50
Kle-sĭl-kwu;[1] creek tributary to upper Skagit, heading with Klehkwunum	121	15
La-yome-sin;[2] creek, tributary to the Chiloweyuck	121	54
Man-sel-pán-ik;[3] creek, tributary to Kle-sil-kwu Creek, heading with Chuch-che-hum	121	15
Moo-yie;[4] camp, monument, river, and trail	116	15
Náĭs-nu-loh; station and river, south fork of Similkameen	120	
Ne-hoi-al-pĭt-kwu;[5] camp and river	118	30
Ne-pó-pe-éh-kum; creek, tributary to the upper Skagit	121	
Nook-sahk; river, Whatcom County, Washington. Now written Nooksak	122	15
N'-shitl-shootl;[6] creek, tributary to Pa-say-ten River	120	40
Okin-á-kane, now written Okanogan; county and river tributary to the Columbia	119	30
O-só-yoos; camp, lake, and station	119	25
Pa-sáy-ten;[7] river tributary to Similkameen	120	30
Pehosie, or Pekosie; lake and creek tributary to the Nooksak	122	05
Pep-táh-shin; creek at [Colville?] depot	118	
Sah-lĭlt-kwu; the forks [of?]. Not identified. Name not on boundary map.		
Se-háĭ-uks; the creek [at Archer's camp of October 10]. Not identified.		
Se-háĭ-ya-kan; Archer's camp of October 10. Not identified.		
Semiahmoo; bay and camp near western end of parallel	122	45
Sen-eh-say;[8] station and creek, tributary to the Chiloweyuck	121	40
Sháh-wa-tum; mountain on upper Skagit	121	
Shwo-yél-pi; Kettle Falls of the Columbia	118	10
Si-mĭl-ka-meen; camp and river tributary to the Okanogan	119	30
Sin-páĭl-hu;[9] creek running south to the Columbia	?118	10
Skagit; cache, camp, county, and river, Washington	122	

[1] Klesilkwa of official map of British Columbia, 1895.
[2] Written Layomesin on boundary map. Sweltzer River of official map of British Columbia, 1895.
[3] Maselpanic, of official map of British Columbia, 1895.
[4] The river is now known as Methow.
[5] Kettle River, of official map of British Columbia, 1895.
[6] Roche River, of official map of British Columbia, 1895.
[7] Pasayton, of official map of British Columbia, 1895.
[8] Slesse, of official map of British Columbia, 1895.
[9] Not shown on boundary map. Land Office map of Washington has Sinpailhu, or Milk Creek (long. 118° 10′), just below Kettle Falls; also San Poil River and guide meridian. This latter is Sans Poil of official map of British Columbia, 1895.

	Approximate longitude.
	° ′
Skits-ooh-nán-na; small creek tributary to the Kootenay; not shown on boundary map	115 05
Skwái-kwi-éht; mountain at head of Chu-chu-wán-ten Creek	120 40
Stat-a-poós-tin; camp on the Ne-hoi-al-pít-kwu	118 15
Stle-kéhm; Mill Creek [? near old Fort Colville, longitude 117° 40′].	
Sumass, now usually written Sumas; camp, lake, town, etc	122 10
Swehl-tchá;[1] lake in British Columbia	122
Swoots-kóse; the Chelemta cache [not on boundary map]. See Yah-kwo-káh-keh.	
Tcho-páhk;[2] mountain west of Camp Similkameen	119 45
Te-kum-whéhl-tin; Archer's camp of October 9; not identified	
Tummeahai;[3] camp and creek tributary to the Chiloweyuck	121 45
Twái-yeep; upper forks of Ne-hoi-al-pít-kwu[4]	119
Wái-haist; mountain on Upper Skagit; not named on boundary map	121
Yah-kwoo-káh-keh; the Chelemta cache. See Swoots-kóse. Not identified.	
Yahk;[5] station and river, Flathead County, Montana	115 45
Yak-ín-a-kahk;[6] creek and pass	114 30
Yakl-tó-le-min; mouth of Pa-say-ten River; not named on boundary map	120 35
Yaks-koo-nák-he;[7] first creek from north below bend of Kootenay	115 30
Yak-toók-i-na;[8] third creek from north tributary to Kootenay, below bend	115 45
Yóme-tsin;[9] White Sheep Creek, tributary to the Columbia	117 50

[1] Cultus of official map of British Columbia, 1895. A creek near by is called Sweltzer.
[2] Tcho Park Mountains of Land Office map of Washington.
[3] Tamihy of official map of British Columbia, 1895.
[4] Apparently junction of Rock Creek and Ne-hoi-al-pít-kwu.
[5] Yahk'h on boundary map.
[6] Yak-in-i-kak on boundary map and Yokinikah of Land Office map of Montana.
[7] Ramy Creek of Land Office map of Montana.
[8] Quartz Creek of Land Office map of Montana.
[9] Sheep Creek of official map of British Columbia, 1895, and Yometsin or Sheep Creek of Land Office map of Washington.

SCIENTIFIC RESULTS.

In the conduct of the survey attention was given to the geology, natural history, etc., of the region traversed. Mr. George Gibbs was attached to the survey as geologist and interpreter, C. B. R. Kennerly as surgeon and naturalist, and James M. Alden as artist. Collections were made and forwarded to Washington. These collections were placed in the hands of specialists, who prepared reports thereon. The nature and extent of these collections can be inferred from the report of the Auditor of the Treasury, already referred to.

It appears from that report that about $3,500 was expended on the preparation of reports on scientific subjects. The persons who prepared those reports, the subjects reported on, and the sums paid are set forth in the following table.[1]

Amounts paid during 1861–62 for work done in the preparation of the scientific part of the final report.

J. S. Harris, report on magnetics, with computations, etc	$743.50
F. B. Meek, report on fossil mollusks, with drawings	375.00
Theodore Gill, report on fishes	300.00
William Stimpson, report on crustaceæ and marine invertebrates	300.00
George Suckley, report on salmonidæ, ornithology, and mammals	300.00
P. B. Carpenter, report on recent mollusks	250.00
J. S. Newberry, report on fossil plants	150.00
Elliot Coues, report on birds, etc	100.00
John Torrey, report on botany	100.00
P. R. Uhler, report on insects	25.00
J. H. Richard, drawings for natural history reports	463.00
John Cassin, eight natural history drawings on stone	160.00
W. B. McMurtrie, drawings for geological reports	100.00
T. Y. Gardner, drawings of fossil plants	65.00
Thomas Egleston, jr., analysis of mineral specimens and preparing catalogue	50.00
Mary B. Codwise, copying natural history papers	12.90
Total	3,494.40

That the reports on these various topics were prepared for insertion in the final report of the commission is abundantly proved. Mr. George Suckley, M. D., assistant surgeon, United States Army, read before the New York Lyceum of Natural History, in June, 1861, a paper entitled "Notices of certain new species of North American salmonidæ, chiefly in the collection of the Northwest Boundary Commission, in charge of Archibald Campbell, esq., commissioner of the United States, collected by Dr. C. B. R. Kennerly, naturalist to the commission."[2] In this paper he says: "Owing to the unfortunate death of Dr. Kennerly on his return from a three-years' exploration, the preparation of a report on certain of the material collected by him was assigned to me. In the course of this undertaking I have prepared a copious synopsis of the species of American salmon and trout, *to appear in the final report of the commissioner.* It has been thought best to issue in advance brief descriptions of the species hitherto unnamed." And later he alludes to papers "to be referred to in the more extended report."

Some of the fossils collected were described by Mr. F. B Meek,[3] who says, "The fossils described in this paper are the new species contained in the collections of the Northwestern Boundary Survey.

[1] House Ex. Doc. No. 86, Fortieth Congress, third session, p. 101.
[2] Annals Lyceum Nat. Hist. New York, vol. 7, pp. 306–313, 1862.
[3] Proc. Acad. Nat. Sci. Phil., vol. 13, pp. 314–318, 1861.

Full illustrations and more extended descriptions of these and other species formerly described by the writer, from Vancouver Island, *will appear in the report of that survey*, which will also contain a report by Mr. George Gibbs, geologist of the expedition, on the general geology of the country along the boundary line."

This full report by Mr. Meek is, so far as I know, still unpublished. Dr. J. S. Newberry's report on the fossil plants seems, however, to have been published in full. At all events, he read, before the Boston Society of Natural History, on October 1, 1862, a paper entitled[1] "Descriptions of the fossil plants collected by Mr. George Gibbs, geologist to the United States Northwest Boundary Commission, under Mr. Archibald Campbell, U. S. Commissioner." This paper, published in February, 1863, "by permission of Archibald Campbell, esq., U. S. commissioner, Northwest Boundary Commission," makes no reference to any other or fuller report. The artist, Mr. James M. Alden, produced a fine series of colored sketches of scenery along the boundary line. These sketches, obviously intended to illustrate the final report, are in the State Department. There are 65 of these, all but two (large ones) included in three portfolios. These sketches and the constantly recurring allusions to the final report, and the conclusive proof that such report was prepared, sharpen the desire and emphasize the need of recovering it.

Whether the geologic report of Mr. Gibbs, alluded to by Mr. Meek, was ever published does not appear. It may be that the rather extensive paper entitled "Physical geography of the northwestern boundary of the United States, by George Gibbs, with twelve illustrations," read before the American Geographical Society November 11, 1869, and published in its journal (vol. 4, pp. 298–392, and vol. 5, pp. 134–157), is the report referred to.

[1] Boston Jour. Nat. Hist., vol. 7, pp. 506–524, 1863.

APPENDIX A

MODE OF DETERMINING POINTS ON THE PARALLEL.

The following is the agreement as to method of determining points on the parallel by measures from the tangent. This agreement and the accompanying table are copied from the original in the State Department.

TO DETERMINE POINTS ON THE FORTY-NINTH PARALLEL BY MEANS OF THE TANGENT.

Wherever points of the parallel between the astronomical stations are to be determined it is hereby agreed to adopt the method of offsets from the tangent to the parallel.

For computing the length of these offsets the following formula is adopted, being that used in computing the difference of latitude of points in secondary triangles or those whose sides do not exceed 12 miles in length:

$$-dL = kB\cos Z + k^2 C \sin^2 Z + h^2 D$$

where

dL=difference of latitude of the two points;

k=length of side connecting them;

$$B = \frac{1}{R \text{ arc } 1''};$$

$$C = \frac{\tan L}{2 N R \text{ arc } 1''};$$

$$D = \frac{\frac{3}{2} e^2 \sin L \cos L \text{ arc } 1''}{(1 - e^2 \sin^2 L)^{\frac{3}{2}}};$$

$h = kB\cos Z$;

$$R = \frac{a(1-e^2)}{(1-e^2 \sin^2 L)^{\frac{3}{2}}};$$

$$N = \frac{a}{(1-e^2 \sin^2 L)^{\frac{1}{2}}};$$

a=equatorial radius of the earth=6 974 127.31 yards;

e=eccentricity=0.081 696 830;

Z=azimuth of tangent counting from south around by west; whence west=90°, east=270°.

This formula becomes in the present case

$$-dL = k^2 C;$$

or, taking offset in yards=δ, distance in yards on the tangent=D

$$\log\delta = 2 \log D + 2.915491.$$

JNO. G. PARKE,
Lieutenant, Corps Topographical Engineers U. S., Chief Astronomer and Surveyor.

R. W. HAIG,
Captain, R. A., Astronomer British Commission.

CAMP SIMIAHMOO, *Forty-ninth Parallel, April 23, 1859.*

Miles.	Offsets.			Miles.	Offsets.		
	Yards.	Feet.	Inches.		Yards.	Feet.	Inches.
0.25	0	0	0.57	5.25	7	0	1.00
.50	0	0	2.29	.50	7	2	1.68
.75	0	0	5.16	.75	8	1	3.49
1.00	0	0	9.18	6.00	9	0	6.45
.25	0	1	2.34	.25	9	2	10.57
.50	0	1	8.65	.50	10	2	3.82
.75	0	2	4.11	.75	11	1	10.23
2.00	1	0	0.72	7.00	12	1	5.78
.25	1	0	10.47	.25	13	1	2.49
.50	1	1	9.37	.50	14	1	0.33
.75	1	2	9.42	.75	15	0	11.33
3.00	2	0	10.61	8.00	16	0	11.47
.25	2	2	0.96	.25	17	1	0.77
.50	3	0	4.45	.50	18	1	3.20
.75	3	1	9.08	.75	19	1	6.79
4.00	4	0	2.87	9.00	20	1	11.52
.25	4	1	9.80	.25	21	2	5.40
.50	5	0	5.88	.50	23	0	0.43
.75	5	2	3.11	.75	24	0	8.60
5.00	6	1	1.48	10.00	25	1	5.93

APPENDIX B.

REPORT OF J. G. PARKE, NOVEMBER 12, 1859.[1]

UNITED STATES BOUNDARY SURVEY, COLVILLE DEPOT,
Washington Territory, November 12, 1859.

SIR: I have the honor respectfully to submit the following report of the progress made during the past season in the survey of the forty-ninth parallel by the several parties of the United States commission:

The organization of the parties throughout the greater part of the season has been as follows: Two astronomical parties, one surveying party, one reconnoissance party.

Mr. G. Clinton Gardner, assistant astronomer and surveyor, in charge of an astronomical party; Professor Nooney, assistant.

Mr. Joseph S. Harris, in charge of second astronomical party; Mr. Hudson, assistant.

Mr. Charles T. Gardner, in charge of the surveying party.

Mr. H. Custer, in charge of the reconnoissance party.

Mr. J. Nevin King, in charge of Chiloweyuck depot, on Fraser river and forwarding supplies to the parties in the field.

Dr. C. B. R. Kennerly, in charge of depot, Chiloweyuck lake, in addition to his duties as surgeon and naturalist.

Mr. George Gibbs, in addition to the geological reconnoissance, had charge of a party engaged in opening a trail through from the Skagit valley to the Similkameen.

Mr. R. V. Peabody, in charge of the subsistence and transportation for the parties to the eastward of the lake depot.

Mr. Major assisted in the computations at the astronomical stations.

The reconnoissance at the close of the last season extended as far east as the valley of the Skagit, and the astronomical observations necessary for marking the three points of the parallel in the valley of the Chiloweyuck were completed. On taking the field the present season, the first object was to complete the measurements and marking the parallel at these three stations, Tummeahai, Chiloweyuck lake, and Chuch-che-hum. Then make reconnoissance for the location of astronomical stations and the opening of trails in advance of the parties occupying these stations.

The first party, under the charge of Mr. G. C. Gardner, left Camp Simiahmoo for the Chiloweyuck depot on the eighteenth day of April.

[1] Reprinted from Senate Ex. Doc. No. 16, 36th Cong., 1st sess., pp. 2-7.

The zenith telescope and transit instrument were put up and observations made for latitude and time. Reconnoitering and surveying parties took the field, with instructions to connect Sumass station with the depot and continue on over the trail, connecting the several astronomical stations, and to obtain the topography of the country along and adjacent to the boundary line. The pack mules were sent from their wintering station to the depot, and arrangements were made for the delivery of subsistence, stores, and forage, at that place.

A chronometer trip was made between Camp Simiahmoo and Chiloweyuck depot by a party under charge of Mr. Harris. Eleven chronometers were transported back and forth, and the entire trip being performed in whale-boats, it is confidently expected that a very nice determination of the difference of longitude will be obtained. The observations for time at the depot were made by Mr. Gardner, and those at Camp Simiahmoo by myself.

On the 19th of May, Mr. Harris left Camp Simiahmoo with the outfit for an astronomical and surveying party. On arriving at the depot, he started for the Tummeahai station, Mr. Custer having previously found a practicable route for a pack trail to that point on the left bank of the Chiloweyuck, it being impracticable at that time to cross the stream opposite the mouth of the Tummeahai. Mr. Custer commenced opening the trail; and, on Mr. Harris taking charge of the party, Mr. Custer continued his reconnoissance over to the Nooksahk, and up the tributaries of the Chiloweyuck.

The trail from the depot to Chiloweyuck lake was reopened and made practicable for pack mules, requiring bridging, corduroying, and heavy grading. The high water of the streams, and the great quantity of fallen timber, made the work very heavy, and required a strong force.

On the third of June I arrived at Chiloweyuck depot, and on the fourth, Mr. G. C. Gardner started for the lake depot. Arriving there, he put the boats in order, built a storehouse for the supplies, and commenced marking the parallel by cutting a vista through the timber across the valley, at the southern end of the lake. On the completion of this, he proceeded to Chuchchehum station, and made a cut there on the parallel, embracing the two crossings of the trail. The parallel at these stations was marked by pyramidal piles of stones from six to eight feet high, covering posts accurately marking points on the line. Mr. Harris marked the parallel in the same manner at the Tummeahai station, having cut a vista through the timber, embracing the two forks of the stream. On the completion of the work at Tummeahai, Mr. Harris proceeded to the lake depot, and commenced opening the trail through to the station on the Skagit river. Here again the work was very heavy, it requiring a force of from ten to eighteen men nearly one month to open about thirty-five miles of trail, of which nearly one-

half had been traveled during the previous year. On reaching the valley of the Skagit Mr. Harris located his observatory, and commenced observations for determining the point where the parallel crosses the river.

While at Chiloweyuck depot, I found that our supply of pack mules was insufficient to enable the parties to progress with the work without great loss of time. Mules, apparejos, and pack-saddles were purchased, and additional packers employed, so that the supplies and outfits of the several parties were carried forward as rapidly as the work progressed and the trail was opened.

On Mr. Gardner's completing the work at Chuchchehum station, we proceeded to make a reconnoissance of the country to the east of Skagit station, with a view of locating astronomical stations and determining a route for a trail through to the Similkameen and Okinakane valleys, a region of country that had been heretofore unexplored and known only to a few Indian hunters. We found a mass of rugged and heavily timbered mountains, extending north and south, and having a breadth of about seventy-five miles. Through by far the greater portion of this distance, no trails were found; but, by dint of constant work of four axemen, we were enabled to force our way through the Similkameen. A good and practicable route was however found, crossing two summits having an elevation of about six thousand feet. A road party was immediately placed upon this route, under charge of of Mr. Gibbs. He was supplied with axes, picks, and shovels; and, after five weeks' labor with a strong force, a trail was opened, so that our instruments and supplies could be packed through without difficulty.

On returning from this reconnoissance Mr. Gardner started with his party to occupy a station on the Similkameen. And Mr. Harris, having completed his determination and marking of the parallel at the Skagit station, proceeded to occupy one nearly midway between the Skagit and Similkameen, on the Pasayten, a tributary of the latter. In the meantime, the survey connecting the astronomical stations was continued by the trail, the nearest practicable line to the parallel, as well as the reconnoissance of the country on both sides of the parallel. On the completion of the observations, computations, and marking the parallel at Pasayten, Mr. Harris's party moved on to the Similkameen, and remained there in camp, while Mr. Harris accompanied me on a reconnoissance, to select another station on the Nehoialpitkwu, about thirty-five miles to the eastward. After reaching the Similkameen, we had no difficulty in traveling, the country being open and grassy, and occupied by horseback Indians; numerous well-worn trails were found running in every direction. One of these we found particularly advantageous, leading eastward from the Similkameen to Fort Colville, on the Columbia river, a distance of about one hundred miles. After

crossing the divide to the east of Lake Osogoos [sic], the trail strikes the Nehoialpitkwu, and follows down the valley of this stream crossing the parallel three times.

From the astronomical station on the Similkameen, two points of the parallel, at an interval of about fifteen miles, were determined and marked by triangulation: one at the crossing of the Similkameen and the other at Lake Osoyoos, in the valley of the Okinakane. The intervening country is generally destitute of timber, and made up of a collection of knobs and high hills with intervening plains and valleys, affording good ground for the location of well conditioned triangles.

The first station on the Nehoialpitkwu was occupied by Mr. Harris, and the parallel was determined by a measurement from the observatory, on the meridian, and marked by a cut, nearly a mile in length, across the valley, and by three monuments—two of earth and one of stone. At this station the stream passes from north to the south of the parallel.

The second station on the Nehoialpitkwu, about thirty miles distant by the trail, is now occupied by Mr. Gardner's party, and Mr. Harris's party is in position on the right bank of the Columbia river, near the mouth of Clarke's Fork. It is believed that these points of the parallel will soon be determined and marked, when these parties, together with the surveying and reconnoitering parties, are instructed to repair to this point and go into winter quarters. The weather, however, is at present very severe, the ground being covered with three or four inches of snow, and the thermometer giving readings for the last three mornings as low as four, two, and ten degrees below zero.

To recapitulate, the following is the amount of work accomplished by parties of the United States commission during the present season:

A completion of the determination and marking the parallel from three points astronomically fixed at the close of the last season.

A complete set of observations for latitude at four stations, from which the parallel has been determined and marked at the crossings of the following streams: the Skagit, Pasayten, Similkameen, Okinakane, (Lake Osoyoos,) and Nehoialpitkwu. And before the astronomical parties leave the field, the necessary observations will be completed for determining two other points of the parallel, the third crossing of the Nehoialpitkwu, and the Columbia river.

A chronometer trip for difference of longitude between Camp Simiahmoo and Chilowayuck depot.

Observations of the transit of the moon and moon-culminating stars at two of the latitude stations for absolute longitude.

A triangulation covering an area of about fifty square miles.

A survey of the nearest practicable lines to the parallel, connecting the astronomical stations, making a total distance chained of about three hundred and seventy miles.

Reconnoissances for developing the topography along and adjacent to the boundary line, and for locating routes of communication. These reconnoissances have extended over an area of about six thousand square miles.

A full set of magnetic observations were made at one station. And throughout the work, all the necessary observations for time, azimuth, micrometer value, and instrumental corrections were carefully made.

The two astronomical parties and the reconnoissance party were furnished with sets of meteorological instruments. Full and detailed registers have been kept at the different stations, and, as far as possible, simultaneous readings of the barometer have been taken, while the parties were moving from station to station; which, with the corresponding observations at camp Simiahmoo and the fixed stations, will enable us to give very exact profiles of the country traversed.

The geological reconnoissance has been extended over the field of operations, and valuable collections made of botanical and natural history specimens.

The forty-ninth parallel, as far as determined during the present season, traverses a mountainous country, and, excepting a few localities, the entire region is eminently unfit for occupation or settlement. The mountains are rugged and precipitous, and attain great elevations; the ridges and peaks of the Cascade mountains being covered with perpetual snow. Glaciers were discovered; and during the months of June and July snow to the depth of two feet was encountered on our very route of travel. A heavy growth of pines and fir abounds throughout the entire line from the Gulf of Georgia, with the exception of short intervals in the valleys of the Similkameen, Okinakane, and Nehoialpitkwu.

Under the forty-ninth parallel the Cascade mountains have a breadth of about two degrees in longitude, and as the general trend of these mountains is at right angles to the line of our work, we were necessarily forced into crossing the ridges with our routes of communication, involving much labor in cutting, grading, and bridging to make these routes practicable for even pack-mule transportation. The water courses are numerous and rapid, rendering the fords frequent and dangerous. A slight rise in these streams makes them impassable. Notwithstanding the difficulties of the country and the precarious mode of transporting the instruments, I am happy to report that we have got thus far through the season's work without any damage to our astronomical instruments. I regret, however, that we have been less fortunate with the magnetic instruments. The mule carrying these missed his footing and rolled down a precipitous bank. The magnetic theodolite will have to be replaced, and the other instruments will require repairing. I also have to report the breakage of our barometer. We were, however, able soon to replace this instrument from the lake depot.

On reaching the valleys of the Similkameen and Okinakane we were met by our additional escort, under the command of Captain Archer, United States army. I take great pleasure in acknowledging my obligations for the timely and valuable assistance rendered us by himself and officers of his command.

Preparations are now making at this place to winter the several parties on their return from the field. A great abundance of material for building quarters is found directly at hand. A supply of provisions has been procured.

The winters of this region are reported to be very severe on animals, the snow falling to a great depth. We have laid in a good stock of hay, and, by erecting temporary shelter, we have little fears of losing any of our mules.

Our work during the next season will extend from the Columbia river to the Rocky mountains. From careful inquiry, the entire distance is represented as mountainous and timbered, excepting perhaps a short stretch in the valley of the Kootenay, near the base of the Rocky mountains. In this valley the Hudson's Bay Company have a trading post near to the parallel. This post is supplied from Fort Colville, and the company's trail to that point will no doubt be of great service to us in sending parties to the line, particularly to those stations close to the Rocky mountains.

In reference to the mode or order of proceeding with the astronomical stations during the next season, I would respectfully suggest that we be allowed to proceed directly to the extreme eastern stations, so that on the melting of the snows, we will be able to complete those, and retire in good season, leaving these nearer this depot for the last. By following this plan we will have less difficulty in falling back on this place, in the event of any great detention or delay from ruggedness of country and swollen streams, or even should the winter set in before the completion of the work. It is confidently expected, however, that we will be able to complete all of the astronomical stations during the next season. Mr. Gibbs is at present making a reconnoissance of the trail in the direction of the Kootenay. This will enable us to commence in the early spring with a working party on this route. It is believed that we will have to build bridges and make flatboats for ferrying Clarke's Fork (Pend d'Oreille) and one of its tributaries, besides much cutting and corduroying.

Before closing this report I take great pleasure in again commending to you the great zeal and devotion to duty evinced by the assistant astronomer and surveyor, and the several assistants engaged upon the work; and I am happy to say that the amount of work accomplished during the season has quite equalled the highest estimates.

I have the honor to be, very respectfully, your obedient servant,

JOHN G. PARKE,

Lieut. Corps Top. Eng's, Chief Astron'r and Surv'r.

APPENDIX C.

REPORT OF ARCHIBALD CAMPBELL, FEBRUARY 3, 1869.[1]

UNITED STATES NORTHWESTERN BOUNDARY COMMISSION.

Washington, D. C., February 3, 1869.

SIR: I have the honor to acknowledge the receipt of your letter of the 16th ultimo, asking for information concerning the matters mentioned in a resolution of the House of Representatives of the 13th of January:

> That the Secretary of State be directed to communicate to the House the total amount expended for the northwestern boundary commission, and to give in detail the items of expenditure, the number and names of persons employed in such commission, how long employed, and at what salaries, and the nature and extent of the services performed.

In reply to your letter I have the honor to transmit herewith the following papers:

Financial statement, January 1, 1869, marked A.

List of persons composing the commission, with rates of salaries, &c., marked B.

List of assistants employed in running and marking the boundary line, with statement of pay, &c., marked C.

List of assistants employed in working up the results of the survey, with statement of pay, &c., marked D.

Statement of labor employed in running and marking the boundary line, marked E.

Statement of services of Indians, marked F.

In regard to "the nature and extent of the services performed," nothing short of the full reports of the chief astronomer and surveyor, and other officers of the commission, and the detailed maps of the survey of the boundary line, can give an adequate idea of the subject. It is not supposed, however, that the House of Representatives desires so comprehensive a reply to their inquiry. I shall therefore endeavor as briefly as possible to furnish the information called for.

On the 11th August, 1856, Congress passed a law, authorizing the appointment of a commission on the part of the United States, to unite with a similar commission to be appointed by Great Britain, for the purpose of carrying into effect the first article of the treaty of June 15,

[1] Reprinted from House Ex. Doc. 86, 40th Congress, 3d session.

1846, that is, to determine and mark the boundary line between the United States and British possessions, agreed upon in the treaty, viz:

> From the point on the 49th parallel of north latitude, where the boundary laid down in existing treaties and conventions between the United States and Great Britain terminates, * * * westward along the said 49th parallel of north latitude, to the middle of the channel which separates the continent from Vancouver's island, and thence southerly, through the middle of the said channel and of Fuca's straits, to the Pacific ocean.

Toward the close of the year the British Government appointed Captain Prevost, royal navy, commanding steamer Satellite, first commissioner to determine that part of the line which runs through "the channel which separates the continent from Vancouver's island," and announced that he had started on his way to the vicinity of the boundary line, and that Captain Richards, royal navy, second commissioner, would shortly follow.

Although the powers of the British commission were limited to the determination of the water-boundary alone, while the act of Congress authorized, on the part of the United States, the determination of the boundary from the crest of the Rocky mountains to the Pacific ocean, the President decided to carry out the law by the appointment of officers authorized thereby, and to notify the British government of the difference between the powers of the two commissions. In February, 1857, I was appointed commissioner, Lieutenant John G. Parke, United States army, chief astronomer and surveyor, and G. Clinton Gardner, assistant astronomer and surveyor, on the part of the United States.

Under instructions from the State Department, the United States commission was duly organized and directed to repair to Fuca's straits, via San Francisco, to meet the British commission. At the close of June, I met Captain Prevost, the British commissioner, at Esquimalt harbor, at the southern end of Vancouver's island, and was informed by him that until the arrival of Captain Richards, second commissioner, with the surveying party, he was not prepared to enter upon the determination of the water boundary. The United States commissioner therefore proceeded to the western terminus of the 49th parallel, on the main land, and established a depot and located an observatory, for the commencement of the survey along the 49th parallel, eastward, to the crest of the Rocky mountains. The British government not yet having provided a commissioner for that part of the boundary line, we were obliged to commence the work without its co-operation. Reconnoissances and explorations in the vicinity of the boundary line were at once commenced, and continued as long as the season permitted field operations. Before the spring, four astronomical points on the 49th parallel were determined, and the country thoroughly reconnoitered in the vicinity of the parallel, for a considerable distance eastward.

Towards the close of October, Captain Prevost visited the 49th parallel and informed me that Captain Richards had not yet arrived, but that, as he had satisfied himself of the general accuracy of the United States Coast Survey chart of the channels and islands between the continent and Vancouver's island, he should act independently of him. He therefore proposed that we should at once proceed to the determination of the water boundary. Several meetings of the joint commission accordingly took place, at which the question of the boundary channel was verbally discussed. The British commissioner claimed Rosario straits (the channel nearest the continent,) while I claimed the Canal de Haro, (the channel nearest Vancouver's island) as the boundary channel, intended by the treaty. Between these two channels lies the Haro archipelago, a group of islands, of which San Juan forms a part.

The verbal discussion was followed by a correspondence on the subject, in which the merits of the question were fully set forth. Captain Prevost concluded the correspondence by a proposition to compromise the difference, by running the boundary through an intermediate channel which would secure the island of San Juan to Great Britain. This proposition I declined.

For more full information in regard to the question of the water boundary I would respectfully refer to Senate Ex. Doc. No. 29, 2d session, 40th Congress. This document contains the correspondence above referred to, with a geographical memoir of the islands in dispute, and a map and cross-sections of the channels.

In conformity with the fifth section of the act organizing the commission, the President (through the Secretary of the Treasury) directed the Superintendent of the Coast Survey to place the steamer Active and brig Fauntleroy at the disposal of the commissioner when required. Both vessels were accordingly employed for the survey and soundings of the various channels and islands between the continent and Vancouver's island, a portion of the expenses of the Active being paid by the commission during the time that vessel was employed on this duty.

After the arrival of the British surveying steamer Plumper, Captain Richards co-operated with the United States Coast Survey vessels, and a thorough and complete survey of all the channels and islands between the continent and Vancouver's island south of the 49th parallel was made.

The map above referred to is the result of this joint survey, which occupied several seasons.

In the summer of 1858 Col. J. S. Hawkins, royal engineers, appointed by the British government commissioner to determine the boundary line along the 49th parallel, arrived from England with a suitable party organized for field operations. At the time of his

arrival the excitement arising from the discovery of gold on Frazer river was at its height. This event caused for a time great increase in the price of labor and supplies, and created considerable embarrassment, delay, and additional expense in the field operations of the season.

A meeting of the joint commission was held for the purpose of agreeing upon a plan of field operations for the survey of the land boundary. The following is a copy of the arrangement made:

After discussing plans for determining and marking the line as far eastward as the Cascade mountains, it was concluded to be inexpedient at the present time, in consequence of the great expense, consumption of time, and the impracticable nature of the country, to mark the whole boundary by cutting a track through the dense forest.

It was therefore agreed to ascertain points on the line by the determination of astronomical points at convenient intervals on or near the boundary, and to mark such astronomical stations, or points fixed on the parallel forming the boundary, by cutting a track of not less than 20 feet in width on each side for the distance of half a mile or more, according to circumstances. Further, that the boundary be determined and similarly marked where it crosses streams of any size, permanent trails, or any striking natural feature of the country.

In the vicinity of settlements on or near the line, it is deemed advisable to cut the track for a greater distance, and to mark it in a manner to be determined hereafter.

The work of running and marking the land boundary was carried on through a country previously almost unknown. The 49th parallel extends over rugged and precipitous mountains that attain great elevation, and in the Cascade range, on and near the boundary, perpetual snow covers many of the peaks, whose northern gorges are filled up with immense glaciers. The timber on the western slope of the Cascade mountains is dense, being a heavy growth of pine and fir, that in many places stands over a fallen forest not yet decayed. This is the character of the country as far east as the valley of the Similkameen river, one of the tributaries of the Columbia. Here the timber becomes more open and surveying operations less difficult.

After passing the Okinokane river, which is the lowest line of the great valley between the Cascade and the Rocky mountains, the country again becomes rough and the timber more dense, but less so than the western slope of the Cascade mountains.

It being impossible to follow the 49th parallel continuously, the line of survey was carried over the nearest practicable route for a pack trail, connecting each astronomical station, making a total length of line of survey of about 800 miles. Astronomical stations were established by parties of the joint commission at almost every accessible point from which the boundary line is ascertained, and marked by a vista across all valleys and trails, where rough stone monuments were erected over posts buried in the ground to indicate the exact line.

The reconnaissance work extends over an area of about 30,000 square miles. Within this space the barometrical heights of over 800 points have been obtained.

A magnetic survey, extending over a range of 3° 20′ in latitude and 4° in longitude, with the necessary observations of the magnetic elements of the astronomical stations, was also made.

The entire length of the land boundary line is over 9° in longitude, or about 410 miles, and the length of the route traveled in surveying it is double that distance. Trails had to be opened for three-fourths of the distance traveled, involving great labor in cutting, grading, and bridging to make the route practicable for pack-mule transportation. The water-courses were numerous and rapid, rendering the fords frequent and dangerous; and a slight rise of many of the streams would have made them impassable but for the timely precaution of building bridges at small streams and ferry boats at the river crossings. Many of the trails opened are now traveled routes to the mines then and since discovered, which are rapidly developing that section of the country, where almost every valley of any extent affords facilities for agricultural pursuits.

In collating the results of the survey reports upon the geology, botany, and natural history of the country reconnoitered were prepared, and complete maps, on a large scale, made of the entire boundary and the adjacent country. A general map has also been made, showing the extent of the country traversed. And to facilitate the survey of the public lands, photographic duplicates of the detailed sheets, showing each monument on the boundary line, with its geographical position, were furnished to the General Land Office. Photographic duplicates of the detailed sheets of the water boundary have also been made and furnished the Department of State in illustration of the question of the boundary channel.

I have the honor to be, very respectfully, your obedient servant,

ARCHIBALD CAMPBELL,
Commissioner Northwest Boundary Survey.

Hon. WILLIAM H. SEWARD,
Secretary of State.

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UNITED STATES GEOLOGICAL SURVEY
CHARLES D. WALCOTT, DIRECTOR

TRIANGULATION AND SPIRIT LEVELING

IN

INDIAN TERRITORY

BY

C. H. FITCH

WASHINGTON
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1900

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LETTER OF TRANSMITTAL.

DEPARTMENT OF THE INTERIOR,
UNITED STATES GEOLOGICAL SURVEY,
Washington, D. C., June 6, 1900.

SIR: I have the honor to transmit herewith, for publication as a bulletin, the results of the primary triangulation and the leveling executed in Indian Territory from 1895 to 1898, inclusive.

Very respectfully,

C. H. FITCH, *Topographer.*

Hon. CHARLES D. WALCOTT,
Director United States Geological Survey.

TRIANGULATION AND SPIRIT LEVELING IN INDIAN TERRITORY.

By C. H. FITCH.

INTRODUCTION.

An act of Congress, approved March 2, 1895, appropriated $200,000 for the survey and subdivision of lands in Indian Territory, and the work was placed, at the discretion of the Secretary of the Interior, in charge of the Director of the Geological Survey.

A plan of operations was approved by the Secretary of the Interior March 21, 1895, Mr. C. H. Fitch was placed in immediate charge of the field work, and preparations were at once made for beginning operations. The requisite instruments, animals, and equipment were soon purchased and a small force took the field about the 1st of April. The force was increased as rapidly as consistent with economic management until about 300 men were engaged in the work of surveying standard, township, and subdivision lines.

The approved plan included the preparation of a topographic map of the area surveyed, which necessitated the execution of a system of triangulation and the running of spirit-level lines, thus affording horizontal and vertical control for the topographic map as well as the linear measurements.

The first parties organized were for the establishment of standard and township exterior lines. Subdivision parties were next organized, each party being divided into two camps with two surveyors in each camp, under the direction of a topographer of the survey whose duties included superintendence of the work of subdivision by the surveyors and the mapping the country subdivided.

An additional appropriation of $200,000 was provided by Congress June 10, 1896, also of $100,000 June 6, 1897, and $30,000 January 28, 1898. The latter amount would probably not have been necessary had the survey progressed without interruption, but the disbanding of the field parties in the spring of 1897, caused by the delay in the provision of funds and the long moves of the parties in the reorganization, added considerably to the expense. A resurvey of the lands of

the Chickasaw Nation was provided for in the act approved June 6, 1897, which appropriated $141,500 for this purpose.

The total amount appropriated for surveys in Indian Territory, which included the lands of the Cherokees, Creeks, Choctaws, and Seminoles, was $530,000, which added to the amount provided for the resurvey of the Chickasaw lands amounts to $671,500.

The total number of miles of standard, township, and subdivisional lines surveyed, from the inception of the work to its completion in June, 1898, was 63,881. The topographic mapping completed at the same time covered an area of 30,885 square miles; in connection with which 133 triangulation stations were established, 9,303 miles of spirit level and 8,594 miles of vertical angles were run, and 920 permanent bench marks were located.

TRIANGULATION.

The base for the triangulation was measured in April, 1895, on a railroad tangent which passes through Savanna, a station on the Missouri, Kansas and Texas Railway, the northern end of the base being about three-fourths of a mile north from Savanna station and 3 miles south from South McAlester. This base was measured twice with a 300-foot steel tape under a tension of 20 pounds, and the temperature of tape determined at each tape length by reading the thermometers. The difference of the two measures (when corrected for difference in temperature) was 0.03 feet.

The resulting length of base, when corrected for temperature, inclination, and reduced to sea level, is 24,893.451 feet, log. meters 3.8800962.

Stations in the expansion were selected on the wooded ridges to the eastward and signals from 25 to 40 feet high erected. The lines between these stations formed bases for the main triangulation, which in 1895 was extended 45 miles southward and 110 miles northward from the base. The triangulation south of Savanna was executed by Mr. S. S. Gannett in May and June, 1895, the triangulation north of Savanna to the Kansas line by Mr. C. F. Urquhart during 1895, 1896, and 1898.

Mr. Urquhart also extended triangulation over the Chickasaw Nation between February and June, 1898. Mr. H. L. Baldwin, jr., controlled the eastern portion of the Choctaw Nation in 1897. Triangulation was extended into Grayson County, Texas, by Mr. Jeremiah Ahern during the latter part of the season of 1898.

The total number of stations occupied by the various observers was 133, the greater number being occupied by Mr. Urquhart.

The instruments used were Fauth theodolites, each having a circle 8 inches in diameter and reading by micrometer microscopes to 2″ of arc.

In most cases the theodolite was elevated from 25 to 60 feet, in order

to see above the timber. An interior tripod, made of 2 by 4 inch scantling, well braced, was first erected; outside of this, and entirely independent of it, a four-sided platform was built for the observer to stand on and also to support the signal, which was above center of tripod.

The total area controlled is about 31,000 square miles.

The geodetic coordinates of all stations were first computed from Savanna astronomic station, using the observed azimuth taken at north base.

Check azimuth observations were made at stations Barber, Harman, Purcell, and Good.

After connections with other astronomic positions had been made, as mentioned below, a mean value dependent upon all four was adopted and a constant correction of +1.08″ in latitude and +10.72″ in longitude was applied to all positions previously computed.

In 1896–97 connection was made with Poteau, Cavanal, Peak, and Sugarloaf, stations of the Arkansas triangulation of 1887, whose positions depend upon a mean value adopted from Fort Smith and Little Rock astronomic stations of the United States Coast and Geodetic Survey.

In 1899, Marlow, the extreme western triangulation station in the Chickasaw Nation, was connected by primary traverse with the astronomic station of the United States Coast and Geodetic Survey at Marlow railroad station.

In December, 1899, Wasson triangulation station, in the northern portion of the Cherokee Nation, was connected by primary traverse with the astronomic station located in 1884 by Prof. R. S. Woodward, United States Geological Survey, at Oswego, Kansas.

Comparisons of positions computed from Savanna with other astronomic locations:

	Latitude difference.	Longitude difference.
	Feet.	*Feet.*
Savanna	+ 0	+ 0
Marlow	+ 201	1,143
Fort Smith and Little Rock	− 267	1,149
Oswego	+ 503	821
	+ 109	+ 778
		+ [1]117
Total		+ 895
Correction	+1.08	+10.72

[1] Longitude increase by Coast and Geodetic Survey adjustment published 1897.

Incidentally to the connection between Wasson triangulation station and Oswego the latitude of the Kansas-Indian Territory boundary line was determined by Mr. E. M. Douglas, in December, 1899, from Oswego, the value 37° 00′ 04.18″ being 422 feet north of the parallel of 37°.

DESCRIPTIONS AND POSITIONS OF STATIONS.

SAVANNA, CHOCTAW NATION (Astronomic station).

Situated on high ground about 300 yards northeast of railroad station at Savanna. The pier is made of brick laid in cement, with its base on solid rock.

Observations for latitude and longitude were made with the Fauth combined transit and zenith telescope, No. 534.

The latitude was determined by Talcott's method, and the Washington Observatory at St. Louis was used as the initial or base station for the longitude determination. The observer at St. Louis was Mr. A. Ramel and at Savanna Mr. S. S. Gannett, the relative personal equation of the observers being determined on two nights in April, 1895, preceding the longitude observations proper, the result showing that Ramel observed later than Gannett 0.075″±0.024″.

The difference of longitude was determined on five nights, the mean being 22′ 32.179″±0.017″.

The resulting longitude west of Greenwich is in arc

95°	50′	21.33″	observed.
		+10.72	
95	50	32.05	geodetic mean.

The mean of 37 results for latitude is

34°	48′	46.49″±0.18″	observed.
	+	1.08	
34	49	47.57	geodetic mean.

North base station was occupied upon one night as an azimuth station, the mark being placed at South base.

SAVANNA NORTH BASE, CHOCTAW NATION.

About three-fourths mile northeast of Savanna railroad station, 60 feet west from and at right angles to west rail of Missouri, Kansas and Texas Railway track, in open country. Theodolite elevated 24 feet.

Station mark: A stone post 36 by 6 by 6 inches, set 30 inches in the ground. Center of station marked by cross cut in the rock.

Reference stones are set to the east, west, and north. Distances from center of station to nearest corners of stones, E. 9.87 feet, W. 10.06 feet, N. 9.64 feet, respectively.

[Latitude, 34° 50′ 22.84″. Longitude, 95° 50′ 12.18″.]

To station.	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
South base	33 43 24.62	213 41 50.02	3.8800962
Johnstown	50 31 31.40	230 30 23.28	3.5940794
Lost	239 54 57.65	59 57 1.39	3.8031660
Hickory	350 44 14.27	170 44 43.88	3.9136236

SAVANNA SOUTH BASE, CHOCTAW NATION.

On a flat summit 4 miles south-southwest of Savanna station; about 3,000 feet south from end of tangent and on line with its prolongation. Theodolite elevated 24 feet.

Station mark: A stone post, 36 by 6 by 6 inches, set 30 inches in the ground. Center of station marked by x cut in the rock.

Reference stones are set to the east, west, and south. Distances from center of station to nearest corners of stones, E. 9.69 feet, W. 10.01 feet, S. 9.49 feet.

[Latitude, 34° 46′ 58.02″. Longitude, 95° 52′ 57.86″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Pine	10 44 37.45	190 43 26.55	4.2306990
Johnstown	197 10 45.03	17 11 11.51	3.6012690
Lost	225 36 58.22	45 40 36.52	4.1330090
Hickory	287 47 59.87	107 49 63.96	3.7642305

JOHNSTOWN, CHOCTAW NATION.

On the wooded ridge about 1½ miles southwest of Savanna. Theodolite elevated 30 feet on the trunk of a tree.

Station mark: A pile of rocks around foot of tall tree trunk, which formed support for instrument. Adjacent trees have side facing center of station, blazed.

[Latitude, 34° 49′ 01.81″. Longitude, 95° 52′ 11.46″.

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Pine	11 58 23.55	191 56 46.25	4.3218489
South base	17 11 11.51	197 10 45.03	3.6012690
Dalton	77 20 17.06	257 11 45.82	4.3683730
Whaleback	108 59 36.48	288 56 06.78	3.9941268
North base	230 30 23.28	50 31 31.40	3.5940794
Lost	236 18 46.96	56 21 58.86	4.0107371
Hickory	322 06 06.26	142 07 43.97	3.8503912

HICKORY, CHOCTAW NATION.

About 4 miles (air line) southeast of Savanna; on a prominent wooded butte. From north boundary of T. 3 N., R. 14 E., at point 30.82 chains east on line between secs. 3 and 34, station bears S. 6° W., 6.04 chains distant. Theodolite elevated 30 feet.

Station mark: A rock marked $\frac{\text{U. S.}}{\text{G. S.}}+$

[Latitude, 34° 46′ 00.32″. Longitude, 95° 49′ 20.30″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Pine	30 15 56.50	210 12 41.79	4.2377005
Dalton	91 01 25.80	270 51 17.21	4.4336560
South base	107 50 03.96	287 47 59.87	3.7642305
Whaleback	122 47 02.83	302 41 55.55	4.2113390
Johnstown	142 07 43.97	322 06 06.26	3.8503912
North base	170 44 43.88	350 44 14.27	3.9136236
Lost	200 20 59.84	20 22 33.85	4.0801000

LOST, CHOCTAW NATION.

On a flat, heavily timbered ridge, about 2 miles east of the Missouri, Kansas and Texas Railway and 4 miles south of South McAlester. A wagon road was cut through the woods, approaching from the gap in the ridge 1 mile south of summit. Theodolite elevated 40 feet.

Station mark: A stone post, 36 by 6 by 6 inches, set 30 inches in the ground, marked thus: U. △S.

[Latitude, 34° 52′ 06.18″. Longitude, 95° 46′ 35.65″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Hickory	20 22 33.85	200 20 59.84	4.0801000
Pine	26 13 33.39	206 08 44.55	4.4654650
South base	45 40 36.52	225 36 58.22	4.1330090
Johnstown	56 21 58.86	236 18 46.96	4.0107371
North base	59 57 01.39	239 54 57.65	3.8031660
Dalton	71 01 02.83	250 49 19.44	4.5201800
Whaleback	82 09 51.07	262 03 09.28	4.2559538
Scipio	152 39 24.59	332 33 47.99	4.5098914
Gaines	215 48 19.74	35 55 03.63	4.4843524
Hewitt	350 55 01.87	170 56 43.85	4.4605759

WHALEBACK, CHOCTAW NATION.

On a long, flat ridge, 8 miles west-northwest of Savanna, about 13 miles southwest of South McAlester. Summit is clear of timber at northern end, but is heavily timbered at southern end. Theodolite elevated 20 feet.

Station mark: A stone post, 26 by 7 by 7 inches, sunk 24 inches in the ground; marked U. △ S.

[Latitude, 34° 50′ 45.85″. Longitude, 95° 58′ 18.64″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Dalton	58 11 07.56	238 06 05.66	4.1994140
Shawnee	123 22 21.34	303 17 09.95	4.2187031
Scipio	183 22 55.57	5 24 02.14	4.4960782
Lost	262 03 09.28	82 09 51.07	4.2559538
Johnstown	288 56 06.78	108 59 36.48	3.9941268
Hickory	302 41 55.55	122 47 02.83	4.2113390
Hewitt	319 10 56.92	139 19 19.36	4.5362443
Pine	348 06 10.04	168 08 01.89	4.3847552

PINE, CHOCTAW NATION.

On the highest part of a long pine-timbered ridge, about 5 miles south of Kiowa. It can best be reached by taking the road from Kiowa to King's sawmill, and where it crosses top of mountain turn south, following the crest about 1½ miles through the woods to the station. Theodolite elevated 50 feet.

Station mark: A hole drilled in the solid rock; marked U. S. G. S.

[Latitude, 34° 37′ 55.69″. Longitude, 95° 55′ 02.35″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Bald	32 45 12.42	212 39 21.00	4.4664448
Indian	52 27 18.16	232 20 14.18	4.3810514
Giant	59 14 40.63	239 02 07.68	4.5960108
Sulser	101 39 21.12	281 24 04.68	4.6218176
Ninas	113 01 14.45	292 50 32.85	4.4935900
Dalton	129 51 37.94	309 44 45.08	4.3806474
Whaleback	168 08 01.89	348 06 10.04	4.3847552
South base	190 43 26.55	10 44 37.45	4.2306990
Johnstown	191 56 46.25	11 58 23.55	4.3218489
Lost	206 08 44.55	26 13 33.39	4.4654650
Hickory	210 12 41.74	30 15 56.50	4.2377005

DALTON, CHOCTAW NATION.

On the highest part of a timbered ridge, about 1 mile north of McAlester's pasture and 1½ miles northeast of a settlement known as Caney Valley. The corner common to secs. 34, 35, 3, and 2, Ts. 3 and 4 N., R. 11 E., may be reached from the station by going due south 18.44 chains, thence S. 82° 30′, W. 32.67 chains. (To change bearings to magnetic declinations add 8° 47′ to each.) Theodolite elevated 30 feet.

Station mark: Rock marked U. S. G. S.

[Latitude, 34° 46′ 14.77″. Longitude, 96° 07′ 07.55″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Indian	1 04 35.71	181 04 23.13	4.4779536
Ninas	72 27 51.21	252 24 01.93	4.0305634
Shawnee	178 42 21.97	358 42 13.02	4.2417862
Whaleback	238 06 05.66	58 11 07.56	4.1994140
Lost	250 49 19.44	71 01 02.83	4.5201800
Johnstown	257 11 45.82	77 20 17.06	4.3683730
Hickory	270 51 17.21	91 01 25.80	4.4336560
Pine	309 44 45.08	129 51 37.94	4.3806474

HEWITT, CHOCTAW NATION.

On a prominent mountain locally known as Bald Mountain, 22 miles by road southwest of Hartshorne and the same distance northeast of Stringtown; 17 miles southeast of Kiowa, at the northeast end of McGee's prairie. The summit is well covered with black jack and pine. The station is situated on highest part, and timber west and northwest of it was cut down.

Station mark: Blazed pine tree.

[Latitude, 34° 36′ 40.72″. Longitude, 95° 43′ 36.72″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Pine	97 35 11.74	277 28 42.20	4.2459604
Whaleback	139 19 19.36	319 10 56.92	4.5362443
Hickory	153 08 03.82	333 04 48.28	4.2863359
Lost	170 56 43.85	350 55 01.87	4.4605759
Hartshorne	215 09 04.93	35 14 24.67	4.3944219
Dexter	271 58 10.85	92 08 49.08	4.4571430
Kosoma	336 43 52.60	156 47 34.00	4.4025800

NINAS, CHOCTAW NATION.

On a timbered ridge, about 2 miles north of South McAlester-Stonewall road, at a point 25 miles from South McAlester, about 3 miles northwest from Mr. Ninas's house. The station may be reached from the corner common to secs. 10, 11, 14, and 15, T. 3 N., R. 10 E., by going N. 0° 2′ W. 20 chains, thence S. 76° 15′ E. 3.57 chains. Theodolite elevated 40 feet.

Station mark: A rock marked $\frac{\text{U. S.}}{\text{G. S.}}$ +

[Latitude, 34° 44′ 29.70″ Longitude, 96° 13′ 49.72″]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Sulser	72 59 14.49	252 54 38.97	4.1096480
Gully (approximate)	131 19 27.50	311 15 29.50	4.14981
Hawkins	142 58 06.97	322 51 47.81	4.4466067
Shawnee	205 22 34.79	25 26 16.86	4.3598037
Dalton	252 24 01.93	72 27 51.21	4.0305633
Pine	292 50 32.85	113 01 14.45	4.4935900
Indian	340 07 02.27	160 10 38.18	4.4549690

SULSER, CHOCTAW NATION.

On a high timbered ridge, about 2 miles west from Coalgate-Allen road, at a point 16 miles from Coalgate. Station may be reached from the quarter corner on line between secs. 28 and 29, T. 3 N., R. 9 E., by going N. 74° 20′ E. 12 chains, thence N. 28° 30′ E. 15.18 chains, thence N. 37° E. 17.34 chains. Theodolite elevated 35 feet.

Station mark: A rock marked $\frac{\text{U. S.}}{\text{G. S.}}$ +

[Latitude, 34° 42′ 27.22″ Longitude, 96° 21′ 53.40″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Gully (approximate)	187 20 58.00	7 21 36.00	4.12057
Ninas	252 54 38.97	72 59 14.49	4.1096480
Pine	281 24 04.68	101 39 21.12	4.6218176
Indian	316 14 38.75	136 22 49.24	4.5032656
Giant	345 49 05.84	165 51 46.50	4.4697694

INDIAN, CHOCTAW NATION.

On the highest oak-timbered hill, about 4 miles northwest of Stringtown, 8 miles north of Atoka, 8 miles northeast of Lehigh, and 3 miles northwest of Sullivan's sawmill. Station may be reached from the closing corner between secs. 2 and 3, T. 1 S., R. 11 E., by going S. 2° E. 20 chains, thence S. 79° 15′ E. 7 chains, thence S. 18° 15′ E. 9 chains, thence S. 3° 15′ E. 5.19 chains. Theodolite elevated 35 feet.

Station mark: An irregularly shaped sand rock set flush with surface of ground and marked $\frac{\text{U. S.}}{\text{G. S.}}$ + Above this is a pile of rocks 3 feet high.

[Latitude, 34° 29′ 59.51″. Longitude, 96° 07′ 29.68″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Giant	69 28 29.56	249 23 00.90	4.1993788
Sulser	136 22 49.24	316 14 38.75	4.5032656
Ninas	160 10 38.18	340 07 02.27	4.4549690
Dalton	181 04 23.13	1 04 35.71	4.4779536
Pine	232 20 14.18	52 27 18.16	4.3810514
Bald	341 55 30.88	161 56 42.87	4.0201200

GIANT, CHOCTAW NATION.

On the highest part of a large, flat, timbered ridge, 3 miles west-southwest of Lehigh. All timber has been cut down, permitting an extensive view in all directions excepting north-northeast. From the corner common to secs. 19, 20, 29, and 30, T. 1 S., R. 10 E., the station may be reached by going N. 8° 47′ E. 7 chains, thence N. 74° 47′ W. 15.59 chains.

Station mark: A post-oak tree, trimmed and standing alone.

[Latitude, 34° 26′ 59.04″. Longitude, 96° 17′ 10.31″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Buffalo	16 34 46.23	196 32 02.36	4.4159775
Sulser	165 51 46.50	345 49 05.84	4.4697694
Pine	239 02 07.68	59 14 40.63	4.4960108
Indian	249 23 00.90	69 28 29.56	4.1993788
Bald	283 37 04.00	103 43 44.23	4.2695412
Forest	306 23 54.12	126 32 10.36	4.4459746
Sugarloaf (2)	327 44 31.13	147 53 10.47	4.6461276
Caddo	357 09 43.02	177 10 26.98	4.6067000

BALD, CHOCTAW NATION.

On a bald hill 3 miles north of Atoka, about 300 feet above and three-fourths mile east of the Missouri, Kansas and Texas Railway. From the quarter corner on line between secs. 1 and 6, T. 2 S., Rs. 11 and 12 E., station may be reached by going due north 4 chains, thence N. 6° 15′ E. 12.28 chains.

Station mark: A flinty sandstone post, 26 by 6 by 8 inches, set 24 inches in ground. Top of rock is marked U. △ S.

[Latitude, 34° 24′ 36.34″. Longitude, 96° 05′ 22.43″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Caddo	24 10 28.68	204 04 34.255	4.5957933
Giant	103 43 44.23	283 37 04.00	4.2695412
Indian	161 56 42.87	341 55 30.88	4.0201200
Pine	212 39 21.00	32 45 12.42	4.4664448
Forest	340 16 23.71	160 18 00.24	4.1125840
Sugarloaf (2)	350 34 44.75	170 36 45.32	4.5253280

FOREST, CHOCTAW NATION.

On the highest land about 10 miles southeast of Atoka in an unbroken forest, one-half mile southwest of cabin occupied by Jim Seever. From the corner common to secs. 9, 10, 15, and 16, T. 3 S., R. 12 E., station bears S. 40° 15′ W., 15.74 chains distant. Theodolite elevated 60 feet.

Station mark: A rock, 39 by 6 by 8 inches, set 36 inches in the ground, marked U. △ S.

[Latitude, 34° 18′ 00.41″. Longitude, 96° 02′ 31.39″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Sugarloaf (2)	356 58 28.94	176 58 53.14	4.3201576
Caddo	40 49 46.98	220 42 16.94	4.4969643
Giant	125 32 10.36	306 23 54.12	4.4459746
Bald	160 18 00.24	340 16 23.71	4.1125840

BUFFALO, CHOCTAW NATION.

On high ground locally known as Buffalo Head, 10 miles west-northwest of Caddo, one-fourth mile west of the Caddo-Wapanucka road, one-eighth mile north of house occupied by Forbes Leflore. The summit is steep on north side, but slopes gently toward the south. From quarter corner on line between secs. 8 and 9, T. 4 S., R. 9 E., station bears N. 67° 07′ E., 25.20 chains distant. Theodolite elevated 30 feet.

Station mark: A sandstone post, 20 by 8 by 8 inches, set 15 inches in very hard, rocky ground.

[Latitude, 34° 13′ 28.36″. Longitude, 96° 22′ 00.84″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Standard section corner..	13 28 19.33	193 26 58.11	4.2019780
Giant	196 32 02.36	16 34 46.23	4.4159775
Sugarloaf (2)	291 48 46.96	112 00 07.96	4.5246785
Caddo	328 27 28.73	148 30 55.68	4.2568325

STANDARD SECTION CORNER, CHOCTAW NATION.

On the open prairie 12 miles southwest of Caddo, on second guide meridian, 29 miles south of land office base line.

Station mark: A wooden post, 6 inches square, projecting 18 inches above ground, with 5 grooves cut on north side and 1 groove on south side; R. 8 E., and S. 25 on northwest side, R. 9 E., and S. 31 on southeast side, T. 5 S., and S. 30 on northeast side, and S. 36 on southwest side.

[Latitude, 34° 05′ 05.83″. Longitude, 96° 24′ 25.52″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Buffalo	193 26 58.11	13 28 19.33	4.2019780
Caddo	269 35 49.89	89 40 37.54	4.1192421

CADDO, CHOCTAW NATION.

On the first hill south of Caddo, being about 3 miles south of that town and 2 miles east of Missouri, Kansas and Texas Railway. The corner common to secs. 28, 29, 32, and 33, T. 5. S., R. 10 E., may be reached from the station by going due west 14.11 chains, thence S. 0° 02′ E. 5.70 chains.

Station mark: A sandstone post, 20 by 8 by 8 inches, set 15 inches in the ground, marked U. △ S.

[Latitude, 34° 05′ 08.52″. Longitude, 96° 15′ 52.23″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Standard section corner..	89 40 37.54	269 35 49.89	4.1192421
Buffalo	148 30 55.68	328 27 28.73	4.2568325
Giant	177 10 26.98	357 09 43.02	4.6067000
Bald	204 04 34.25	24 10 28.68	4.5957933
Forest	220 42 16.94	40 49 46.98	4.4969643
White Rock	239 47 08.75	60 06 18.14	4.7813130
Sugarloaf (2)	262 16 03.77	82 23 56.86	4.3389841

SUGARLOAF (2), CHOCTAW NATION.

On a sharp, bare peak 15 miles east of Caddo; a prominent and well-known landmark in that part of the nation. The corner common to secs. 14, 15, 22, and 23, T. 5 S., R. 12 E., may be reached from the station by going due east 25.90 chains, thence N. 0° 01′ W. 8.43 chains.

Station mark: A rock cairn 4 feet high.

[Latitude, 34° 06′ 43.04″. Longitude, 96° 01′ 48.35″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Caddo	82 23 56.86	262 16 03.77	4.3389841
Buffalo	112 00 07.96	291 48 46.96	4.5246785
Giant	147 53 10.47	327 44 31.13	4.6461276
Bald	170 36 45.32	350 34 44.75	4.5253280
Forest	176 58 53.14	356 58 28.94	4.3201576
White Rock	228 12 30.30	48 23 45.33	4.6141214
Goodland	277 38 34.00	97 53 16.15	4.6098760

WHITE ROCK, CHOCTAW NATION.

A high, flat mountain about 5 miles west of the St. Louis and San Francisco Railroad and 9 miles by road northwest of Rodney. The summit is level for several miles and covered with tall pine trees. The station is located near the northwest end of the summit, about one-fourth mile northwest of head of log chute and three-fourths mile northwest of Herndon's sawmill. The quarter corner between secs. 23 and 26, T. 2 S., R. 15 E., may be reached from the station by

going due north 8.91 chains to section line, thence due west 16.70 chains. Theodolite elevated 60 feet.

Station mark: A flint rock 1 foot square on top, 3½ feet long, and set 2 feet in the ground. Rock marked U. △ S.

[Latitude, 34° 21′ 30.92″. Longitude, 95° 41′ 48.46″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Sugarloaf	48 23 45.33	228 12 30.30	4.6141214
Caddo	60 06 18.14	239 47 08.75	4.7813130
Forest	78 33 36.05	258 21 55.11	4.5109320
Goodland	343 43 15.78	163 46 46.13	4.5343770

GOODLAND, CHOCTAW NATION.

On a high, flat prairie ridge owned by Tom Self, 4 miles west of Goodland and 1 mile north of road from Goodland to forks of Boggy Creek. From quarter corner between secs. 1 and 2, T. 6 S., R. 16 E., station bears S. 79° 25′ W., 11.68 chains distant.

Station mark: Shell rocks piled around foot of tall signal pole.

[Latitude, 34° 03′ 44.44″. Longitude, 95° 35′ 34.34″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Sugarloaf (2)	97 53 16.15	277 38 34.00	4.6098760
White Rock	163 46 46.13	343 43 15.78	4.5343770

GULLY, CHOCTAW NATION.

A timbered hill in northwestern portion of Choctaw Nation.

The station was not occupied, but all timber was cut down in 1895, leaving a lone tree as a signal. The corner common to secs. 9, 10, 15, and 16, T. 4 N., R. 9 E., may be reached from station by going due north 97 links and due east 32.10 chains.

Station mark: Lone signal tree.

[Latitude, 34° 49′ 32.06″. Longitude, 96° 20′ 46.96″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Sulser	7 21 36	187 20 58	4.12057
Ninas	311 15 30	131 19 28	4.14981

SHAWNEE, CHOCTAW NATION.

On a high timbered point about 3 miles north from where Choctaw, Oklahoma and Gulf Railroad crosses Coal Creek. The corner common to secs. 2, 3, 10, and 11, T. 5 N., R. 11 E., may be reached from station by going S. 43° 43′ W. 3.79½ chains. Theodolite elevated 36 feet.

Station mark: Rock marked $\frac{\text{U. S.}}{+}$ $\frac{}{\text{G. S.}}$

[Latitude, 34° 55′ 40.88″. Longitude, 96° 07′ 23.07″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Dalton	358 42 13.02	178 42 21.97	4.2417852
Ninas	25 26 16.86	205 22 34.79	4.3598040
Hawkins	93 34 21.35	273 24 19.90	4.4265922
Bruner	126 10 31.06	306 02 01.66	4.4451958
Blanket	180 59 59.13	1 00 09.04	4.3988600
Scipio	217 05 12.59	37 11 31.71	4.4430075
Lost	281 42 00.50	101 53 54.14	4.5099472
Whaleback	303 17 09.95	123 22 21.34	4.2187031

HAWKINS, CREEK NATION.

On a timbered ridge about 5 miles north of Allen, about 1 mile north of Canadian River, and 1 mile west from Mr. Hawkins's residence. Station is 4.2 chains north of town line between Ts. 5 and 6 N., R. 8 E., and 37.5 chains east of line between secs. 35 and 36. Theodolite elevated 65 feet.

Station mark: Rock marked $\frac{\text{U. S.}}{+}$ $\frac{}{\text{G. S.}}$

[Latitude, 34° 56′ 33.63″. Longitude, 96° 24′ 53.39″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Wewoka	165 19 14.59	345 15 32.26	4.5860074
Bruner	195 31 05.57	15 32 38.63	4.1864990
Shawnee	273 24 19.90	93 34 21.35	4.4265922
Ninas	322 51 47.81	142 58 06.97	4.4466067

BRUNER, CREEK NATION.

On a timbered ridge about 2 miles east from Holden, a small town on Choctaw, Oklahoma and Gulf Railroad, and three-fourths mile north of Berry Bruner's residence. The corner common to secs. 16, 17, 20, and 21, T. 7 N., R. 9 E., may be reached from station by going due west 1.95 chains, thence due south 20.05 chains. Theodolite elevated 50 feet.

Station mark: Rock marked $\frac{\text{U. S.}}{+}$ $\frac{}{\text{G. S.}}$

[Latitude, 35° 04′ 33.89″. Longitude, 96° 22′ 11.17″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Hawkins	15 32 38.63	195 31 05.57	4.1864090
Wewoka	148 20 51.31	328 15 35.18	4.4220464
Blanket	249 18 47.67	69 27 28.44	4.3890809

BLANKET, CREEK NATION.

On a timbered ridge about 13 miles southwest from Proctor and about 1 mile south from Allen-Eufaula road at point where road enters the hills going southwest. The corner common to secs. 22, 23, 26, and 27, T. 8 N., R. 11 E., may be reached from station by going due west 22.70 chains, thence due south 47.96 chains. Theodolite elevated 38 feet.

Station mark: Rock marked $\frac{\text{U. S.}}{+}$ $\frac{}{\text{G. S.}}$

[Latitude, 35° 09′ 13.74″. Longitude, 96° 07′ 05.80″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Bruner	69 27 28.44	249 18 47.67	4.3890809
Wewoka	110 46 03.01	290 32 04.48	4.5944177
Bean	169 46 42.33	349 44 31.44	4.5078207
Rentie	194 21 08.03	14 24 34.36	4.5600038
Tiger	233 37 59.83	53 46 48.92	4.4590231
Scipio	280 11 06.93	100 17 17.19	4.2187340
Shawnee	1 00 09.04	180 59 59.13	4.3988600

SCIPIO, CHOCTAW NATION.

On a prominent wooded butte on south side of Canadian River just west of the mouth of Scipio Creek. It is best approached from the southeast side. The quarter corner on line between secs. 33 and 34, T. 8 N., R. 13 E., may be reached from station by going due east 45.25 chains, thence due south 19.15 chains.

Station mark: Rock marked U. S. + G. S.

[Latitude, 35° 07′ 38.31″. Longitude, 95° 56′ 22.54″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Shawnee	37 11 31.71	217 05 12.59	4.4430075
Blanket	100 17 17.19	280 11 06.93	4.2187340
Tiger	199 06 26.88	19 09 04.84	4.3251235
Badger	218 01 30.50	38 08 36.40	4.4809116
Gaines	276 52 32.20	97 04 54.93	4.5178375
Lost	332 33 47.99	152 39 24.59	4.5098914
Whaleback	5 24 02.14	185 22 55.57	4.4960782

GAINES, CHOCTAW NATION.

On a long wooded ridge about 10 miles northeast of McAlester and 7 miles southeast of South Canadian. A wagon road was cut through the woods to station from north end of ridge. The quarter corner to secs. 10 and 14, T. 7 N., R 16 E., may be reached from station by going due south 22.51 chains, thence due west 19.55 chains. Theodolite elevated 30 feet.

Station mark: Rock marked U. S. + G. S.

[Latitude, 35° 05′ 28.40″. Longitude, 95° 34′ 51.13″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Lost	35 55 03.63	215 48 19.74	4.4843524
Scipio	97 04 54.93	276 52 32.20	4.5178375
Tiger	133 03 04.79	312 53 18.25	4.5462527
Badger	153 20 57.63	333 15 38.62	4.4933600
Checotah	182 27 43.81	2 28 21.63	4.5851466
Hartshorne	358 24 31.69	178 24 52.33	4.5183389
Tucker Knob	275 30 53.06	95 40 05.60	4.3886690
Enterprise	226 00 53.24	46 07 03.25	4.3536994

HARTSHORNE, CHOCTAW NATION.

On a flat, heavily wooded mountain about 4 miles south of Hartshorne, a town on the Choctaw, Oklahoma and Gulf Railroad. Most of the timber was cut down in April, 1895.

Station mark: Tall pine signal tree.

[Latitude, 34° 47′ 38.36″. Longitude, 95° 34′ 15.10″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Hewitt	35 14 24.67	215 09 04.93	4.3944219
Lost	113 44 21.12	293 37 18.15	4.3127665
Gaines	178 24 52.33	358 24 31.69	4.5183389
Tucker Knob	217 26 30.29	37 35 20.15	4.5861956
Redoak	234 09 44.63	54 23 35.08	4.6567634
Dexter	326 03 29.37	146 08 49.37	4.4091583

BADGER, CREEK NATION.

On a high prairie point locally known as Badger Mountain, 10 miles west of Eufaula. The corner common to secs. 8, 9, 16, and 17, T. 10 N., R. 15 E., may be reached from station by going due east 4.85 chains to the north-south line between secs. 16 and 17, thence due north 33.14 chains to corner.

Station mark: Rock marked $\frac{\text{U. S.}}{\text{G. S.}}+$

[Latitude, 35° 20′ 31.26″. Longitude, 95° 44′ 04.31″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Scipio	38 08 36.40	218 01 30.50	4.4809116
Tiger	71 52 39.46	251 48 11.00	4.0913890
Council Hill	175 51 06.08	355 50 26.81	4.3724920
Checotah	235 44 48.55	55 50 46.86	4.2760000
Gaines	333 15 38.62	153 20 57.63	4.4933600
Chimney	214 51 02.85	35 00 51.93	4.6497068

TIGER, CREEK NATION.

On a wooded ridge, about 3 miles north from Cummings's store, which is 20 miles from Eufaula, on Eufaula-Wetumka road. The corner common to secs. 29, 30, 31, and 32, T. 10 N., R. 14 E., may be

reached from station by going due east 30.68 chains to north-south line between secs. 29 and 30, thence due north 15.16 chains to corner. Theodolite elevated 40 feet.

Station mark: Rock marked $\frac{\text{U. S.}}{\text{G. S.}}$ +

[Latitude, 35° 18′ 26.45″. Longitude, 95° 51′ 48.61″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Scipio	19 09 04.84	199 06 26.88	4.3251235
Blanket	53 46 48.92	233 37 59.83	4.4590231
Rentie	142 06 28.55	322 01 04.10	4.3616769
Council Hill	200 03 04.43	20 06 54.34	4.4643900
Badger	251 48 11.00	71 52 39.46	4.0913890
Gaines	312 53 18.25	133 03 04.79	4.5462527

RENTIE, CREEK NATION.

On a prominent mountain, 4 or 5 miles east from Morris Rentie's house. Mr. Rentie lives 14 miles from Okmulgee, on Okmulgee-McDermott road. Theodolite elevated 38 feet.

Station mark: Rock marked $\frac{\text{U. S.}}{\text{G. S.}}$ +

[Latitude, 35° 28′ 14.98″. Longitude, 96° 01′ 08.82″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Blanket	14 24 34.36	194 21 08.03	4.5600038
Bean	76 43 08.80	256 37 30.32	4.1795973
McDermott	93 54 27.56	273 44 35.08	4.4114903
Buck	183 58 12.43	3 58 59.30	4.4656679
Council Hill	248 59 13.94	69 08 29.82	4.4118748
Tiger	322 01 04.10	142 06 28.55	4.3616769

BEAN, CREEK NATION.

On the highest part of a timbered ridge, 7 miles southwest from Morris Rentie's and 4 miles northeast from McDermott. The corner common to secs. 7, 8, 17, and 18, T. 11 N., R. 11 E., may be reached from station by going S. 51° 08′ E., 29.53 chains. Theodolite elevated 38 feet.

Station mark: Rock marked $\frac{\text{U. S.}}{\text{G. S.}}$ +

[Latitude, 35° 26′ 21.88″. Longitude, 96° 10′ 52.32″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Wewoka	60 11 47.16	239 59 56.76	4.5533090
McDermott	115 18 38.41	295 14 24.69	4,0861590
Philips	161 33 41.15	341 29 17.64	4.5559096
Slicker	185 56 33.15	5 58 23.18	4.6605192
Buck	207 04 12.40	27 10 38.80	4.5642776
Rentie	256 37 30.32	76 43 08.80	4.1795973
Blanket	349 44 31.44	169 46 42.33	4.5078207

M'DERMOTT, CREEK NATION.

On a high prairie ridge, 7 miles northwest from McDermott. The corner common to secs. 13, 18, 19, and 24, T. 12 N., R. 9 E., may be reached from station by going due north 40 chains, thence S. 88° E. 15.80 chains.

Station mark: Rock marked $\frac{\text{U. S.}}{+}$

[Latitude, 35° 29′ 10.83″. Longitude, 96° 18′ 09.63″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Wewoka	40 57 33.57	220 49 55.98	4.4838314
Philips	179 13 51.81	359 13 42.78	4.4610444
Buck	225 12 47.84	45 23 29.08	4.5910136
Rentie	273 44 35.08	93 54 27.56	4.4114903
Bean	295 14 24.69	115 18 38.41	4.0861590

PHILIPS, CREEK NATION.

On the highest point of a ridge 2½ miles southwest of Philipsburg. The quarter corner between secs. 24 and 25, T. 15 N., R. 9 E., may be reached from station by going due north 46.50 chains, thence S. 80° 30′ W. 4.15 chains. Theodolite elevated 35 feet.

Station mark: Rock marked $\frac{\text{U. S.}}{+}$

[Latitude, 35° 44′ 48.79″. Longitude, 96° 18′ 25.07″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Phantom	185 08 22.08	5 09 32.36	4.5250097
Slicker	234 39 23.83	54 45 39.10	4.2952760
Buck	272 55 34.92	93 06 27.21	4.4487212
Bean	341 29 17.64	161 33 41.15	4.5559096
McDermott	359 13 42.78	179 13 51.81	4.4610444

SLICKER, CREEK NATION.

On the highest point of a timbered ridge 10 miles south of Sapulpa. The corner common to secs. 22, 23, 26, and 27, T. 16 N., R. 11 E., may be reached from station by going due east 35.19 chains to north-south line, thence due south 37.13 chains. Theodolite elevated 30 feet.

Station mark: Rock marked $\frac{\text{U. S.}}{+}$
G. S.

[Latitude, 35° 50′ 58.77″. Longitude, 96° 07′ 43.51″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Bean	5 58 23.18	185 56 33.15	4.6605192
Philips	54 45 39.10	234 39 23.83	4.2952760
Phantom	149 16 21.79	329 11 15.53	4.4075133
Red Fork	196 32 28.97	16 35 52.47	4.4832632
Prairie	212 57 39.81	33 00 57.80	4.1916511
Concharty	268 29 43.14	88 42 30.97	4.5172609
Buck	317 09 01.96	137 13 39.87	4.2445088

COUNCIL HILL, CREEK NATION.

On the highest point of a timbered ridge, near the old Creek camping ground known as Council Hill, 20 miles northwest of Checotah, 16 miles southeast of Okmulgee. From closing corner to secs. 5 and 6, T. 12 N., R. 15 E., station may be reached by going N. 46° 01′ W. 15.47 chains. Theodolite elevated 40 feet.

Station mark: Rock marked $\frac{\text{U. S.}}{+}$
G. S.

[Latitude, 35° 33′ 14.29″. Longitude, 95° 45′ 12.03″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Tiger	20 06 54.34	200 03 04.43	4.4643900
Rentie	69 08 29.82	248 59 13.94	4.4118748
Buck	132 10 36.83	312 02 06.04	4.4729877
Concharty	178 15 58.87	358 15 35.01	4.5266554
Chimney	244 15 19.04	64 25 49.08	4.4801495
Checotah	306 39 30.76	126 46 09.33	4.3340941
Badger	355 50 26.81	175 51 06.08	4.3724920

CHECOTAH, CREEK NATION.

On a prairie hill 3 miles southwest of Checotah, a town on the Missouri, Kansas and Texas Railway. From quarter corner on line between secs. 12 and 13, T. 11 N., R. 16 E., station bears N. 38° 55′ E. 17.80 chains distant.

Station mark: A rock marked $\frac{\text{U. S.}}{+}$ $\frac{}{\text{G. S.}}$

[Latitude, 35° 26′ 15.65″. Longitude, 95° 33′ 45.61″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Badger	55 50 46.86	235 44 48.55	4.2760000
Council Hill	126 46 09.33	306 39 30.76	4.3340941
Chimney	200 56 57.80	21 00 47.78	4.4443800
Gaines	2 28 21.63	182 27 43.81	4.5851466
Tucker Knob	330 54 23.74	151 03 00.85	4.6691536
Enterprise	327 20 21.69	147 25 55.37	4.4319011
Robinson	290 25 39.72	110 35 09.18	4.4230683
Nebo	240 27 44.88	60 34 14.95	4.2891939

CHIMNEY, CREEK NATION.

On the highest point of a prairie hill locally known as Chimney Mountain, 8 or 10 miles southwest of Muscogee.

Station mark: A tree wired up, to which all angles are referred.

Reference mark: Rock marked $\frac{\text{U. S.}}{+}$ $\frac{}{\text{G. S.}}$ 5 feet west-northwest of tree.

[Latitude, 35° 40′ 18.52″. Longitude, 95° 27′ 10.08″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Checotah	21 00 47.78	206 56 57.80	4.4443800
Badger	35 00 51.93	214 51 02.85	4.6497068
Council Hill	64 25 49.08	244 15 19.04	4.4801495
Concharty	126 08 47.59	305 57 51.63	4.5425065
Grand	230 26 08.37	50 35 12.03	4.4812237
Choate	270 04 36.12	90 27 02.85	4.7640609
Nebo	336 58 36.97	157 01 17.93	4.2507681

CONCHARTY, CREEK NATION.

On a high knob in the southeastern portion of the Concharty Mountains, 4 miles northeast of Concharty. From corner common to secs. 13, 18, 19, and 24, on eastern boundary of T. 16 N., R. 14 E., station bears N. 63° E., 4 chains distant. Theodolite elevated 50 feet.

Station mark: Rock marked $\frac{\text{U. S.}}{\text{G. S.}}$ +

[Latitude, 35° 51′ 24.53″. Longitude, 95° 45′ 52.43″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Council Hill	358 15 35.01	178 15 58.87	4.5266554
Buck	56 57 41.33	236 49 32.51	4.3988766
Slicker	88 42 30.97	268 29 43.14	4.5172608
Prairie	116 42 33.87	296 33 02.96	4.4362032
Weer	175 20 16.00	355 19 30.49	4.3773732
Barber	247 34 42.92	67 45 53.06	4.5210429
Grand	271 14 31.71	91 34 33.92	4.7120103
Chimney	305 57 51.63	126 08 47.59	4.5425065

BUCK, CREEK NATION.

On a high ridge 9 miles a little west of north of Okmulgee. The corner common to secs. 35, 36, 1, and 2, T. 15 N., R. 12 E., may be reached from station by going due west 26 links to north-south line, thence due south 38.38 chains. Theodolite elevated 30 feet.

Station mark: Rock marked $\frac{\text{U. S.}}{\text{G. S.}}$ +

[Latitude, 35° 44′ 00.81″. Longitude, 95° 59′ 48.31″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Rentie	3 58 59.30	183 58 12.43	4.4656679
Bean	27 10 38.80	207 04 12.40	4.5642776
McDermott	45 23 29.08	225 12 47.84	4.5910136
Philips	93 06 27.21	272 55 34.92	4.4487212
Slicker	137 13 39.87	317 09 01.96	4.2445088
Prairie	172 25 24.99	352 24 04.40	4.4174915
Concharty	236 49 32.51	56 57 41.33	4.3988766
Council Hill	312 02 06.04	132 10 36.83	4.4729877

MERCHANT, CREEK NATION.

On a very prominent prairie hill about 1½ miles northeast from Inola, a station on the St. Louis, Iron Mountain and Southern Railway. From quarter corner on line between secs. 9 and 10, T. 19 N., R. 17 E., station bears N. 54° 30′ E., 41.07 chains distant.

Station mark: Rock monument 7 feet high.

[Latitude, 36° 08′ 42.58″. Longitude, 95° 29′ 07.50″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Weer	73 08 57.47	252 58 19.50	4.4518697
Grand	321 38 24.35	141 48 40.13	4.6270376
Barber	344 09 40.46	164 11 49.69	4.3043975
McGinnis	134 01 12.44	313 53 07.78	4.4539608
Corbett	189 12 37.68	9 13 03.50	3.8340395
Saline	266 22 21.40	86 38 36.97	4.6170996

WEER, CREEK NATION.

On the highest one of several small prairie hills 6 miles north of Weer post-office and store. The corner common to secs. 1, 2, 11, and 12, T. 18 N., R. 14 E., may be reached from station by going due east 34.64 chains to north-south line, thence south 52.68 chains.

Station mark: Signal tree.

[Latitude, 36° 04′ 15.01″. Longitude, 95° 47′ 10.07″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Prairie	62 52 06.41	242 43 19.61	4.4017803
Red Fork	101 46 24.03	281 37 41.43	4.3553486
Merchant	252 58 19.50	73 08 57.47	4.4518697
Concharty	355 19 30.49	175 20 15.97	4.3773732
Tulsa	122 49 00.53	302 39 44.40	4.4476239
McGinnis	193 10 20.92	13 12 56.02	4.4585858
Dog Creek	221 35 43.95	41 48 22.82	4.6830193
Corbett	241 53 34.36	62 04 38.55	4.5037586

PRAIRIE, CREEK NATION.

On a prairie knob 5 miles east of Sapulpa. The corner common to secs. 9, 10, 15, and 16, T. 17 N., R. 12 E., may be reached from station by going due east 28.30 chains to north-south line, thence south 41.54 chains.

Station mark: Rock marked U. S. + G. S.

[Latitude, 35° 58′ 01.88″. Longitude, 96° 02′ 05.92″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Slicker	33 00 57.80	212 57 39.81	4.1916511
Phantom	112 34 54.96	292 26 29.81	4.3672550
Red Fork	180 46 50.04	0 46 55.21	4.2074900
Weer	242 43 19.61	62 52 06.41	4.4017803
Concharty	296 33 02.96	116 42 33.87	4.4362032
Buck	352 24 04.40	172 25 24.99	4.4174915
Tulsa	177 28 19.97	357 27 52.19	4.4267742

RED FORK, CREEK NATION.

On a timbered ridge three-fourths mile west from Red Fork. The corner common to secs. 21, 22, 27, and 28, T. 19 N., R. 13 E., may be reached from station by going due east 17.95 chains to north-south line, thence south 41.80 chains. Theodolite elevated 30 feet.

Station mark: Rock marked U. S. + G. S.

[Latitude, 36° 06′ 44.99″. Longitude, 96° 01′ 57.14″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Prairie	00 46 53.21	180 46 50.04	4.2074900
Slicker	16 35 52.47	196 32 28.97	4.4832632
Phantom	71 43 14.27	251 34 43.06	4.3595162
Weer	281 37 41.43	101 46 24.03	4.3553486

PHANTOM, CREEK NATION.

On the highest part of a timbered ridge 15 miles from Red Fork, 5 miles southwest of Mr. Rockhammer's house. The corner common to secs. 7, 8, 17, and 18, T. 18 N., R. 10 E., may be reached from station by going due west 24.90 chains to north-south line, thence south 2.25 chains. Theodolite elevated 40 feet.

Station mark: Rock marked $\frac{\text{U. S.}}{+}$ $\frac{}{\text{G. S.}}$

[Latitude, 36° 02′ 51.26″. Longitude, 96° 16′ 25.20″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Philips	5 09 32.36	185 08 22.08	4.5250097
Red Fork	251 34 43.06	71 43 14.27	4.3595162
Prairie	292 26 29.81	112 34 54.96	4.3672550
Slicker	329 11 15.53	149 16 21.79	4.4075133

WEWOKA, SEMINOLE NATION.

On a prominent wooded hill 8 miles north-northwest of Wewoka, from which all trees have been cut down, excepting one, which was trimmed and used as a signal. The corner common to secs. 1, 2, 11, and 12, T. 9 N., R. 7 E., may be reached from station by going due south 16.92 chains to east-west line, thence west 35.06 chains on line to corner.

Station mark: Lone signal tree.

Reference mark: Rock marked $\frac{\text{U. S.}}{+}$ $\frac{}{\text{G. S.}}$ 3 feet west of signal tree.

[Latitude, 35° 16′ 43.53″. Longitude, 96° 31′ 19.91″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
McDermott	220 49 55.98	40 57 33.57	4.4838314
Bean	239 59 56.76	60 11 47.16	4.5533090
Blanket	290 32 04.48	110 46 03.01	4.5944177
Bruner	328 15 35.18	148 20 51.31	4.4220467
Hawkins	345 15 32.26	165 19 14.59	4.5860074

TURKEY SPRING, CHICKASAW NATION.

On a flat timbered ridge 5 miles a little east of north from Iona post-office, on Iona-Hart road, about 54 yards east from road. The quarter-section corner between secs. 4 and 9, T. 2 N., R. 3 E., true azimuth of which is 56° 26′, is distant from station 514 feet. Theodolite elevated 44 feet.

Station mark: A stone post, 26 by 6 by 6 inches, set 24 inches in the ground, with copper bolt marked $\begin{matrix}\text{U. S.}\\ +\\ \text{G. S.}\end{matrix}$ sunk in center of top.

[Latitude, 33° 40′ 00.72″. Longitude, 96° 59′ 29.59″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Center	210 40 45.68	30 43 48.54	4.2039410
Double Mound	265 27 22.42	85 35 24.28	4.3350359
Hickory Grove	315 37 36.52	135 42 22.89	4.2644222
Falls	27 32 57.77	207 27 36.67	4.4950993
Bounds	48 39 51.04	228 29 05.61	4.5877258
Table Hills	90 51 30.05	270 34 20.49	4.6635548
Washington	142 58 42.56	322 52 22.28	4.4491675

HICKORY GROVE, CHICKASAW NATION.

On summit of timbered hill 1¼ miles southeast from town of Hickory. Point is locally known as Hickory Grove. The corner common to secs. 13, 14, 23, and 24, T. 1 N., R. 4 E., true azimuth of which is 255° 30′, is distant from station 2,320 feet. Theodolite elevated 40 feet.

Station mark: A rock found in place about 2 feet square, 3 or 4 inches above ground, a hole drilled 1 inch deep near center of rock and filled with lead. A large $\begin{matrix}\text{U. S.}\\ +\\ \text{G. S.}\end{matrix}$ cut on rock around center.

[Latitude, 34° 32′ 53.99″. Longitude, 96° 51′ 05.38″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Mill Creek	5 18 49.48	185 18 11.56	4.2667531
Falls	61 59 09.76	241 49 03.68	4.4908862
Turkey Spring	135 42 22.89	315 37 36.52	4.2644222
Double Mound	210 27 07.44	30 30 22.15	4.2359485
Kennedy	224 48 45.67	44 53 11.02	4.2274279
Pontotoc	278 53 40.55	99 02 20.76	4.3746222
Reagan	316 17 48.34	136 23 47.21	4.3699816

REAGAN, CHICKASAW NATION.

On high prairie point in northwest corner of Harris's pasture, about 4½ miles northeast from Reagan post-office. About 1½ miles west from Tishomingo-Stonewall road at point 11 miles from (Old) Tishomingo. The corner common to secs. 9, 10, 15, and 16, T. 2 S., R. 6 E., true azimuth of which is 318° 39′, is distant from station 2,312.6 feet.

Station mark: A stone post, 30 by 7 by 7 inches, set 27 inches in the ground, with copper bolt marked $\frac{\text{U. S.}}{\text{G. S.}}$ + sunk in center of top.

[Latitude, 34° 23′ 43.55″. Longitude, 96° 40′ 31.32″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Teller	7 30 36.39	187 29 30.27	4.3615846
Provence	47 23 52.41	227 12 48.55	4.6131505
Mill Creek	85 27 00.60	265 20 24.64	4.2544722
Hickory Grove	136 23 47.21	316 17 48.34	4.3699816
Pontotoc	208 35 59.02	28 38 39.50	4.1793967
Giant	260 19 57.29	80 33 09.27	4.5596544

MILL CREEK, CHICKASAW NATION.

On highest point of prairie ridge, 2 miles south of and visible from Mill Creek post-office. Point is covered with limestone rock. The corner common to secs. 9, 10, 15, and 16, T. 2 S., R. 4 E., true azimuth of which is 135° 02′, is distant from station 4,295 feet.

Station mark: A stone post, 26 by 6 by 6 inches, set 24 inches in the ground, with copper bolt marked $\frac{\text{U. S.}}{\text{G. S.}}$ + sunk in center of top.

[Latitude, 34° 22′ 56.75″. Longitude, 96° 52′ 12.38″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Provence	24 54 06.30	204 49 37.24	4.4635652
Criner	46 44 39.50	226 33 22.63	4.6265169
Falls	98 33 05.83	278 23 38.88	4.4135521
Hickory Grove	185 18 11.56	5 18 49.48	4.2667531
Reagan	265 20 24.64	85 27 00.60	4.2544722
Teller	324 59 42.62	145 05 11.43	4.4158821

KENNEDY, CHICKASAW NATION.

On high, bald ridge about 8 miles west from Stonewall. The Stonewall-Roff road passes within 50 yards of station at point 8 miles from former. Station is on the north side of fence. The quarter-section corner between secs. 7 and 12, T. 2 N., Rs. 5 and 6 E., true azimuth of which is 183° 55′, is distant from station 900 feet.

Station mark: A stone post, 30 by 8 by 8 inches, set 27 inches in the ground, with a copper bolt marked $\frac{\text{U. S.}}{\text{G. S.}}$ + sunk in center of top.

[Latitude, 34° 39′ 22.41″. Longitude, 96° 43′ 18.12″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Hickory Grove	44 53 11.02	224 48 45.67	4.2274279
Double Mound	132 09 30.35	312 08 19.53	3.6309344
Sulser	260 01 14.71	80 13 25.73	4.5210877
Pontotoc	323 43 23.24	143 47 38.93	4.2882158
Giant	299 41 26.54	119 56 15.74	4.6634185

CENTER, CHICKASAW NATION.

On prairie 1 mile south from Center-McGee road at point 5 miles from Center. Station is not on the highest point, but three-fourths mile south from it. The corner common to secs. 20, 21, 28, and 29, T. 4 N., R. 4 E., true azimuth of which is 217° 26′, is distant from station 2,791.8 feet.

Station mark: A stone post, 26 by 6 by 6 inches, set 24 inches in the ground, with a copper bolt marked $\frac{\text{U. S.}}{\text{G. S.}}$ + sunk in center of top.

[Latitude, 34° 47′ 26.98″. Longitude, 96° 54′ 08.58″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Double Mound	311 59 42.83	132 04 42.52	4.2556380
Turkey Spring	30 43 48.54	210 40 45.68	4.2039410

DOUBLE MOUND, CHICKASAW NATION.

About 1 mile north of road between Stonewall and Roff at point 9 miles from Stonewall, on most northern of two prairie hills known as the Double Mounds. The corner common to secs. 34, 35, 2, and 3, Ts. 2 and 3 N., R. 5 E., true azimuth of which is 9° 24′, is distant from station 553.7 feet.

Station mark: A rock monument about 7 feet high.

[Latitude, 34° 40′ 55.51″. Longitude, 96° 45′ 22.61″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Kennedy	312 08 19.53	132 09 30.35	3.6309344
Hickory Grove	30 30 22.15	210 27 07.44	4.2359485
Turkey Spring	85 35 24.28	265 27 22.42	4,3350359
Center	132 04 42.52	311 59 42.83	4.2556380

WASHINGTON, CHICKASAW NATION.

On high ridge, a portion of which is covered with timber, about miles northeast from Paoli, a small town on the Gulf, Colorado and Santa Fe Railway, about 1 mile south from road between Johnson and Purcell, at point 7 miles west from former. The corner common to secs. 25, 26, 35, and 36, T. 5 N., R. 1 E., true azimuth of which is 185° 40′, is distant from station 290 feet.

Station mark: A stone post, 42 by 8 by 8 inches, set 38 inches in the ground, copper bolt marked $\frac{\text{U. S.}}{\text{G. S.}}$ sunk in center.

[Latitude, 34° 52′ 09.06″. Longitude, 97° 10′ 36.45″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Bounds	14 03 42.38	193 59 14.37	4.6948367
Table Hills	53 08 07.47	232 57 15.59	4.5608000
Purcell	122 35 38.65	302 26 22.45	4.4657995
Turkey Spring	322 52 22.28	142 58 42.56	4.4491675
Falls	357 04 13.48	177 05 10.62	4.7010726

PURCELL, CHICKASAW NATION.

On high prairie ridge 6 miles west from Purcell. The Purcell-Chickasha road passes 1 mile south from station. The quarter-section corner between secs. 7 and 8, T. 6 N., R. 2 W., true azimuth of which is 299° 18′, is distant from station 1,933 feet.

Station mark: A stone post, 26 by 7 by 7 inches, set 24 inches in the ground, with copper bolt marked $\frac{\text{U. S.}}{\text{G. S.}}$ + sunk in center of top.

[Latitude, 35° 00′ 38.92″. Longitude, 97° 26′ 47.65″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Washington	302 26 22.45	122 35 38.65	4.4657995
Table Hills	6 38 31.16	186 36 52.96	4.5778655
Dibble	108 12 05.06	288 04 47.35	4.3082296

DIBBLE, CHICKASAW NATION.

On point with scattering timber near prairie, 2¾ miles northwest of Dibble. The quarter-section corner between secs. 19 and 20, T. 7 N., R. 4 E., true azimuth of which is 287° 41′, is distant from station 1,902 feet. Theodolite elevated 34 feet.

Station mark: A stone post, 30 by 6 by 6 inches, set 27 inches in the ground, with copper bolt marked $\frac{\text{U. S.}}{\text{G. S.}}$ + sunk in center of top.

[Latitude, 35° 04′ 04.37″. Longitude, 97° 39′ 30.03″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Purcell	288 04 47.35	108 12 05.06	4.3082296
Table Hills	341 05 42.68	161 11 20.28	4.6665312
Marlow	28 28 13.04	208 19 49.32	4.6723677

MARLOW, CHICKASAW NATION.

On a sand hill covered with small black-jack trees about 5 miles northeast from Marlow, a town on Chicago, Rock Island and Pacific Railway. Road between Marlow and Rush Springs passes 2 miles west from station at point 4 miles from Marlow. Can be seen from both Marlow and Rush Springs. The corner common to secs. 25, 26, 35, and 36, T. 3 N., R. 7 W., true azimuth of which is 255° 43′, is distant from station 2,245 feet.

Station mark: A stone post, 30 by 7 by 7 inches, set 27 inches in the ground, with copper bolt marked $\frac{\text{U. S.}}{\text{G. S.}}$ + sunk in center of top.

[Latitude, 34° 41′ 41.90″. Longitude, 97° 54′ 10.85″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Dibble	208 19 49.32	28 28 13.04	4.6723677
Table Hills	273 45 57.14	93 59 54.38	4.5744916
Velma	325 13 14.67	145 20 40.59	4.5463148

TABLE HILLS, CHICKASAW NATION.

On a high timbered ridge about 4 miles north from Foster post-office, about 1 mile southwest from a flat-topped prairie hill, the highest of several hills locally known as "The Table Hills." The corner common to secs. 2, 3, 10, and 11, T. 2 N., R. 3 E., true azimuth of which is 339° 25′, is distant from station 1,955.2 feet.

Station mark: A stone post, 30 by 6 by 6 inches, set 27 inches in the ground, with copper bolt marked $\frac{\text{U. S.}}{\text{G. S.}}$ + sunk in center of top.

[Latitude, 34° 40′ 19.40″. Longitude, 97° 29′ 39.52″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Velma	33 34 32.37	213 28 03.67	4.5002213
Marlow	93 59 54.38	273 45 57.14	4.5744916
Dibble	161 11 20.28	341 05 42.68	4.6665312
Purcell	186 36 52.96	6 38 31.16	4.5778655
Washington	232 57 15.59	53 08 07.47	4.5608000
Turkey Spring	270 34 20.49	90 51 30.05	4.6635548
Falls	311 39 31.21	131 51 16.40	4.6284726
Bounds	326 45 23.84	146 51 44.83	4.4953517

BOUNDS, CHICKASAW NATION.

On high prairie ridge near center of Arbuckle Mountains, in pastur[illegible] owned by Mr. Bounds, about 6 miles a little north of east from El[illegible] post-office. Road between Woodford and Hennepin passes one-hal[illegible] mile east from station at point 7 miles from former. The corne[illegible] common to secs. 21, 22, 27, and 28, T. 1 S., R. 1 W., true azimuth [illegible] which is 281° 02′, is distant from station 2,627 feet.

Station mark: A stone post, 26 by 7 by 7 inches, set 24 inches in the ground, with copper bolt marked $\frac{U.\ S.}{G.\ S.}$ + sunk in center of top.

[Latitude, 34° 26′ 09.71″. Longitude, 97° 18′ 27.77″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Bomer	25 31 01.46	205 25 18.23	4.5591404
Velma	89 47 04.84	269 34 17.46	4.5396891
Table Hills	146 51 44.83	326 45 23.84	4.4953517
Washington	193 59 14.37	14 03 42.38	4.6948367
Turkey Spring	228 29 05.61	48 39 51.04	4.5877258
Falls	278 14 36.70	98 20 00.00	4.1689755
Criner	344 43 47.36	164 47 17.30	4.5595469

FALLS, CHICKASAW NATION.

On high timbered hill known as "East Timber Hill," about 7 miles a little west of south from Davis, on the Gulf, Colorado and Santa Fe Railway. All timber cut from summit except one tree, which was left for signal. The quarter corner between secs. 1 and 36, Ts. 1 and 2 S., R. 1 E., true azimuth of which is 151° 26′, is distant from station 1,232 feet.

Station mark: Lone signal tree.

[Latitude, 34° 25′ 00.67″. Longitude, 97° 08′ 55.90″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Criner	8 49 30.83	188 47 38.72	4.5219151
Bomer	44 44 19.94	224 33 14.71	4.6333908
Bounds	98 20 00.00	278 14 36.70	4.1689755
Table Hills	131 51 16.40	311 39 31.21	4.6284726
Washington	177 05 10.62	357 04 13.48	4.7010726
Turkey Spring	207 27 36.67	27 32 57.77	4.4950993
Hickory Grove	241 49 03.68	61 59 09.76	4.4908862
Mill Creek	278 23 38.88	98 33 05.83	4.4135521
Provence	335 57 43.01	156 02 39.05	4.5192812

VELMA, CHICKASAW NATION.

On northwest corner of high timbered ridge about 9 miles north from Loco post-office, about 3 miles south from Velma, a post-office on Wild Horse Creek, 5 miles below Arthur post-office. The corner

common to secs. 25, 26, 35, and 36, T. 1 S., R. 5 W., true azimuth of which is 238° 08′, is distant from station 271 feet.

Station mark: A stone post, 30 by 7 by 7 inches, set 27 inches in the ground, with copper bolt marked $\frac{U.\ S.}{G.\ S.}$ sunk in center of top.

[Latitude, 34° 26′ 03.39″. Longitude, 97° 41′ 04.85″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Mud Creek	5 57 32.56	185 56 19.93	4.5025994
Marlow	145 20 40.59	325 13 14.67	4.5463148
Table Hills	213 28 03.67	33 34 32.37	4.5002213
Bounds	269 34 17.46	89 47 04.84	4.5396891
Bomer	329 28 46.75	149 35 48.03	4.5766564

MUD CREEK, CHICKASAW NATION.

On high prairie ridge in Washington's pasture, 13 miles south from Loco post-office and 7 miles west from Cornish post-office. Road between Loco and Oscar passes 50 yards east of station. The corner common to secs. 3, 4, 9, and 10, T. 5 S., R. 5 W., true azimuth of which is 347° 14′, is distant from station 1,800 feet.

Station mark: A stone post, 30 by 7 by 7 inches, set 27 inches in the ground, with copper bolt marked $\frac{U.\ S.}{G.\ S.}$ sunk in center of top.

[Latitude, 34° 08′ 56.49″. Longitude, 97° 43′ 13.77″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Velma	185 56 19.93	5 57 32.56	4.5025994
Bomer	272 10 17.03	92 18 29.13	4.3517708

BOMER, CHICKASAW NATION.

On a very flat timbered ridge 5 miles southwest from Hewitt post-office. Road between Hewitt and Atlee passes three-fourths mile north from station at point 4½ miles from Hewitt. About 2 miles southwest from point known as "Bomers Point." The corner common to secs. 1, 2, 11, and 12, T. 5 S., R 3 W., true azimuth of which is 218° 21′, is distant from station 1,419 feet.

Station mark: A stone post, 30 by 7 by 7 inches, set 27 inches in the ground, with copper bolt marked $\frac{\text{U. S.}}{\text{G. S.}}$ + sunk in center of top.

[Latitude, 34° 08′ 27.98″. Longitude, 97° 28′ 37.03″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″.	*Meters.*
Mud Creek	92 18 29.13	272 10 17.03	4.3517708
Velma	149 35 48.03	329 28 46.75	4.5766564
Bounds	205 25 18.23	25 31 01.46	4.5591404
Falls	224 33 14.71	44 44 19.94	4.6333908
Criner	275 06 01.87	95 15 12.86	4.4025346

CRINER, CHICKASAW NATION.

On high prairie ridge 6 miles southwest from Ardmore. Road from Ardmore to Brook post-office passes within one-half mile of station at point where it crosses Hickory Creek. The station is south of this point, and can be seen from Ardmore. The quarter corner between secs. 15 and 16, T. 5 S., R. 1 E., true azimuth of which is 258° 06′, is distant from station 3,010 feet.

Station mark: A stone post, 24 by 7 by 7 inches, set 22 inches in the ground, with copper bolt marked $\frac{\text{U. S.}}{\text{G. S.}}$ + sunk in center of top.

[Latitude, 34° 07′ 13.98″. Longitude, 97° 12′ 15.02″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Bomer	95 15 12.86	275 06 01.87	4.4025346
Bounds	164 47 17.30	344 43 47.36	4.5595469
Falls	188 47 38.72	8 49 30.83	4.5219151
Mill Creek	226 33 22.63	46 44 39.50	4.6265169
Provence	261 46 24.86	81 53 11.50	4.2732401
Marietta	333 55 54.13	153 59 48.74	4.3893686

MARIETTA, CHICKASAW NATION.

On a prominent prairie peak 2 miles southeast from town of Marietta on the Gulf, Colorado and Santa Fe Railway. The corner common to secs. 21, 22, 27, and 28, T. 8 S., R. 2 E., true azimuth of which is 148° 09′, is distant from station 1,777 feet.

Station mark: A rock monument 6 feet high.

[Latitude, 33° 55′ 19.18″. Longitude, 97° 05′ 15.67″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Criner	153 59 48.74	333 55 54.13	4.3893686
Provence	197 34 50.80	17 37 41.72	4.4133530
Cliff	253 36 40.99	73 48 51.42	4.5436688

PROVENCE, CHICKASAW NATION.

On a round prairie hill the most prominent of the prairie hills known as the "Yellow Hills." One mile southeast from Provence post-office. The corner common to secs. 4, 5, 8, and 9, T. 5 S., R. 3 E., true azimuth of which is 347° 49′, is distant from station 282 feet.

Station mark: A stone post, 30 by 7 by 7 inches, set 28 inches in the ground, with copper bolt marked $\frac{\text{U. S.}}{\text{G. S.}}$ + sunk in center of top.

[Latitude, 34° 08′ 40.52″. Longitude, 97° 00′ 10.28″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Marietta	17 37 41.72	197 34 50.80	4.4133530
Criner	81 53 11.50	261 46 24.86	4.2732401
Falls	156 02 39.05	335 57 43.01	4.5192812
Mill Creek	204 49 37.24	24 54 06.30	4.4635652
Teller	259 26 15.23	79 36 11.42	4.4417207
Cliff	300 00 24.74	120 09 46.16	4.4726143

CLIFF, CHICKASAW NATION.

On a prairie ridge 2½ miles southwest from Cliff post-office, and about the same distance northeast from Kingston post-office. Road between Cliff and Kingston passes one-fourth mile from station. The corner common to secs. 19, 24, 25, and 30, T. 6 S., Rs. 5 and 6 E., true azimuth of which is 162° 15′, is distant from station 1,006.5 feet.

Station mark: A stone post, 30 by 7 by 7 inches, set 28 inches in the ground, with copper bolt marked $\frac{\text{U. S.}}{\text{G. S.}}$ + sunk in center of top.

[Latitude, 34° 00′ 37.47″. Longitude, 96° 43′ 28.30″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Marietta	73 48 51.42	253 36 40.99	4.5436688
Provence	120 09 46.16	300 00 24.74	4.4726143
Teller	184 23 02.16	4 23 35.58	4.3004052

TELLER, CHICKASAW NATION.

On a high timbered ridge locally known as "Big Mush Mountain," 3½ miles a little west of south from Tishomingo and 1 mile east from Teller post-office. Ridge breaks off abruptly to the north and slopes gradually south. The corner common to secs. 19, 20, 29, and 30, T. 4 S., R. 6 E., true azimuth of which is 317° 11′, is distant from station 1,268 feet.

Station mark: A stone post, 30 by 7 by 7 inches, set 28 inches in the ground, with copper bolt marked $\frac{\text{U. S.}}{\text{G. S.}}$ sunk in center of top.

[Latitude, 34° 11′ 23.75″. Longitude, 96° 42′ 28.68″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Cliff	4 23 35.58	184 23 02.16	4.3004052
Provence	79 36 11.42	259 26 15.23	4.4417207
Mill Creek	145 05 11.43	324 59 42.62	4.4158821
Reagan	187 29 30.27	7 30 36.39	4.3615846

PONTOTOC, CHICKASAW NATION.

On a high bare limestone ridge 2½ miles northeast from Pontotoc post-office, 2 miles east from road between Stonewall and Pontotoc at a point 10 miles from Stonewall. The quarter corner between secs. 29 and 30, T. 1 N., R. 7 E., true azimuth of which is 45° 02′, is distant from station 981 feet.

Station mark: A copper bolt marked $\frac{\text{U. S.}}{\text{G. S.}}$ sunk in a large limestone rock found in place.

[Latitude, 34° 30′ 54.14″. Longitude, 96° 35′ 47.67″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Reagen	28 38 39.50	208 35 59.02	4.1793967
Hickory Grove	99 02 20.76	278 53 40.55	4.3746222
Kennedy	143 47 38.93	323 43 23.24	4.2882158
Sulser	224 47 54.19	44 55 48.06	4.4790149
Giant	284 10 03.04	104 20 35.63	4.4686086

ENTERPRISE, CHOCTAW NATION.

On a high hill in T. 9 N., R. 18 E., about 1 mile west from the town of Enterprise. All timber, with the exception of one tree, was cut from the summit of hill and the tree left standing was used for signal.

Station mark: Lone signal tree.

[Latitude, 35° 13′ 56.75″. Longitude, 95° 24′ 08.66″.]

To station—	Azimuth.	Back azimuth	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Gaines	46 07 03.25	226 00 53.27	4.3536994
Checotah	147 25 55.37	327 20 21.69	4.4319011
Nebo	184 14 11.38	4 15 06.44	4.5110605
Robinson	217 13 52.15	37 17 46.84	4.2292121
Cavanal	284 59 47.36	105 24 47.52	4.8347026
Tucker Knob	335 52 44.55	155 55 48.17	4.2960739
Choate	227 44 10.22	48 04 44.53	4.8592724

TUCKER KNOB, CHOCTAW NATION.

About 13 miles north from Wilburton, a small town on the Choctaw, Oklahoma and Gulf Railroad, and about 12 miles a little south of west from Sansbois. All timber with the exception of 1 tree was cut from summit of peak, and the tree left standing was used for signal. From the corner common to secs. 16, 17, and 21, T. 7 N., R. 19 E., station may be reached by going due south 1,095 feet, thence due west 122.6 feet.

Station mark: Lone signal tree.

[Latitude, 35° 04′ 11.03″. Longitude, 95° 18′ 49.74″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Gaines	95 40 05.62	275 30 53.09	4.3886687
Checotah	151 03 00.85	330 54 23.74	4.6691536
Enterprise	155 55 48.17	335 52 44.55	4.2960739
Nebo	173 36 57.38	353 34 48.08	4.7051448
Robinson	183 59 48.83	4 00 39.15	4.4999404
Redoak	287 04 00.84	107 09 02.70	4.1441831

ROBINSON, CHEROKEE NATION.

On high, flat-topped ridge in T. 10 N., 19 E., about 3 miles a little south of west from Starvilla. Theodolite elevated 20 feet.

Station mark: A stone post, 30 by 7 by 7 inches, set 28 inches in the ground, with copper bolt marked $\frac{\text{U. S.}}{\text{G. S.}}$ sunk in center of top.

[Latitude, 35° 21′ 14.51″. Longitude, 95° 17′ 22.45″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Tucker Knob	4 00 39.15	183 59 48.83	4.4999404
Enterprise	37 17 46.84	217 13 52.15	4.2292121
Checotah	110 35 09.18	290 25 39.72	4.4230683
Nebo	157 26 01.25	337 23 00.86	4.3101779
Choate	230 58 47.11	51 15 27.30	4.7461712
Cavanal	299 16 44.36	119 37 52.55	4.8054100
Redoak	342 40 55.60	162 45 08.23	4.5720205

NEBO, CHEROKEE NATION.

On highest part of flat ridge locally known as Nebo Mountain, about 12 miles northeast from Checotah and about 5 miles west of north from Burnett post-office. From corner common to secs. 10, 11, 14, and 15, T. 12 N., R. 18 E., station bears N. 60° 03′ E., 17.31 chains distant. Theodolite elevated 30 feet.

Station mark: A stone post, 24 by 7 by 7 inches, placed 8 inches in the ground, with copper bolt marked $\frac{\text{U. S.}}{\text{G. S.}}$ sunk in center.

[Latitude, 35° 31′ 26.45″. Longitude, 95° 22′ 33.56″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Enterprise	4 15 06.44	184 14 11.38	4.5110605
Checotah	60 34 14.95	240 27 44.88	4.2891939
Chimney	157 01 17.93	336 58 36.97	4.2507681
Grand	204 42 01.02	24 48 22.41	4.5940012
Choate	252 20 28.17	72 40 11.52	4.7296388
Cavanal	308 11 52.46	128 36 03.09	4.9081524
Robinson	337 23 00.86	157 26 01.25	4.3101779
Redoak	340 46 34.57	160 53 47.42	4.7611543
Tucker Knob	353 34 48.04	173 36 57.38	4.7051448

REDOAK, CHOCTAW NATION.

On highest point of flat-topped mountain known as Redoak Mountain, about 7 miles northwest from Redoak, a small town on Choctaw, Oklahoma and Gulf Railroad. From the corner common to secs. 2, 3, 34, and 35, on south boundary, T. 7 N., R. 20 E., station may be reached by going due north 21.10 chains, thence east 22.88 chains (to point 45 links east of center of station). Theodolite elevated 20 feet.

Station mark: Post-oak signal tree.

[Latitude, 35° 01′ 57.96″. Longitude, 95° 10′ 04.12″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Tucker Knob	107 09 02.70	287 04 00.84	4.1441831
Nebo	160 53 47.42	340 46 34.57	4.7611543
Robinson	162 45 08.23	342 40 55.60	4.5720205
Cavanal	264 27 03.81	84 43 55.20	4.6515599
Hartshorne	54 23 35.08	234 09 44.63	4.6567634
Dexter	25 22 22.06	205 13 54.57	4.7230759
Winding Stair	318 56 13.09	139 05 31.03	4.5768480

CHOATE, CHEROKEE NATION.

On highest point of high, flat-topped mountain about 3 miles west of Bunch, a very small town on Kansas City, Pittsburg and Gulf Railroad. From the corner common to secs. 19, 24, 25, and 30, T. 14 N., R. 23 E., station may be reached by going west 20.22 chains and north 9.30 chains. Theodolite elevated 42 feet.

Station mark: A stone post, 24 by 8 by 8 inches, placed 22 inches in the ground, with copper bolt marked $\frac{\text{U. S.}}{\text{G. S.}}$ + sunk in center of top.

[Latitude, 35° 40′ 10.11″. Longitude, 94° 48′ 40.38″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Cavanal	349 40 23.73	169 45 00.14	4.8292412
Enterprise	48 04 44.53	227 44 10.22	4.8592724
Robinson	51 15 27.30	230 58 47.11	4.7461712
Nebo	72 40 11.52	252 20 28.17	4.7296388
Chimney	90 27 02.85	270 04 36.12	4.7640609
Grand	119 30 07.47	299 16 41.44	4.5995755
Spade	201 48 16.56	21 51 57.17	4.4062574

CAVANAL, CHOCTAW NATION.

On Cavanal Mountain, a well-known point about 4 miles west of Poteau, a town on Kansas City, Pittsburg and Gulf Railroad. The corner common to secs. 16, 17, 20, and 21, T. 7 N., R. 25 E., may be reached from station by going due west 11.49 chains to the north-south line, thence north 10.75 chains.

Station mark: Copper bolt set in sandstone rock.

[Latitude, 35° 04′ 15.08″. Longitude, 94° 40′ 43.06″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Redoak	84 43 55.20	264 27 03.81	4.6515599
Enterprise	105 24 47.52	284 59 47.36	4.8347026
Robinson	119 37 52.55	299 16 44.36	4.8054100
Nebo	128 36 03.09	308 11 52.46	4.9081524
Choate	169 45 00.14	349 40 23.73	4.8292416
Winding Stairs	31 26 09.15	211 18 39.19	4.5834269

GRAND, CHEROKEE NATION.

On high timbered ridge about 5 miles northeast from Fort Gibson, a town on St. Louis, Iron Mountain, and Southern Railway. The road from Fort Gibson to Melvin passes about 200 yards east of station. From the corner common to secs. 20, 21, 28, and 29, T. 16 N., R. 20 E., station may be reached by going north 0° 02′ W. 7 chains, thence N. 54° 33′ E. 17.50 chains. Theodolite elevated 40 feet.

Station mark: A stone post, 24 by 8 by 8 inches, with copper bolt marked $\begin{matrix} U.\ S. \\ + \\ G.\ S. \end{matrix}$ sunk in center of top.

[Latitude, 35° 50′ 43.41″. Longitude, 95° 11′ 39.74″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Nebo	24 48 22.41	204 42 01.02	4.5940012
Chimney	50 35 12.03	230 26 08.37	4.4812237
Concharty	91 34 33.92	271 14 31.71	4.7120103
Barber	123 48 12.76	303 40 07.04	4.3974645
Merchant	141 48 40.13	321 38 24.35	4.6270376
Corbett	147 55 54.08	327 46 03.56	4.6743218
Salina	202 55 33.73	23 01 29.85	4.5895756
Spade	264 29 41.79	84 46 50.98	4.6460932
Choate	299 16 41.44	119 30 07.47	4.5995755

SPADE, CHEROKEE NATION.

On high timbered hill known as Spade Mountain, 7 or 8 miles northwest from Stillwell, a town on Kansas City, Pittsburg and Gulf Railroad. From the quarter corner on line between secs. 1 and 12, T. 16 N., R. 24 E., station may be reached by going S. 89° 39′ E. 11.63 chains, thence due south 12.62 chains. Theodolite elevated 20 feet. Highest trees were cut from the summit of the hill.

Station mark: A stone post, 24 by 8 by 8 inches, placed 22 inches in the ground, with copper bolt marked $\begin{matrix}\text{U. S.}\\ +\\ \text{G. S.}\end{matrix}$ sunk in center.

[Latitude, 35° 52′ 57.64″. Longitude, 94° 42′ 23.01″.]

To station—	Azimuth.	Back azimuth.	Log. distauce.
	° ′ ″	° ′ ″	*Meters.*
Choate	21 51 57.17	201 48 16.56	4.4062574
Grand	84 46 50.98	264 29 41.79	4.6460932
Salina	137 46 20.77	317 35 03.85	4.6314574
Kansas	165 54 43.46	345 50 55.29	4.5995950
Baptist	213 19 54.66	33 24 08.59	4.2945621

SALINA, CHEROKEE NATION.

On highest point of rolling timbered hills about 3½ miles southwest from Salina court-house. From point 32.95 chains north, on line between secs. 35 and 36, T. 20 N., R. 21 E., station may be reached by going due east 9.50 chains. Theodolite elevated 40 feet.

Station mark: A stone post, 24 by 7 by 7 inches placed 22 inches in the ground, with copper bolt marked $\frac{\text{U. S.}}{\text{G. S.}}$ + sunk in center of top.

[Latitude, 36° 10′ 04.41″. Longitude, 95° 01′ 33.97″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Grand	23 01 29.85	202 55 33.73	4.5895755
Merchant	86 38 36.97	266 22 31.40	4.6170996
Corbett	96 06 44.50	275 50 54.04	4.6068569
Dog Creek	124 56 53.98	304 42 34.65	4.6449413
Spavinaw	168 36 29.33	348 34 55.09	4.3035865
Round Springs	207 39 50.86	27 44 59.35	4.4469067
Kansas	249 58 38.63	69 06 09.42	4.3072366
Spade	317 35 03.85	137 46 20.77	4.6314574

BARBER, CREEK NATION.

On a small prairie mountain 3 miles northwest of Wagoner. The corner common to secs. 7, 8, 17, and 18, T. 17 N., R. 18 E., may be reached from station by going S. 84° 30′ E., 14.56 chains to north-south line, thence south 60 chains.

Station mark: A rock marked $\frac{\text{U. S.}}{\text{G. S.}}$ + sunk in ground flush with surface.

[Latitude, 35° 58′ 13.40″. Longitude, 95° 25′ 27.94″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Concharty	67 45 53.06	247 34 42.92	4.5210429
Merchant	164 11 49.69	344 09 40.46	4.3043975
Corbett	170 27 26.89	350 25 43.32	4.4231780
Grand	303 40 07.04	123 48 12.76	4.3974645

BAPTIST, CHEROKEE NATION.

On a lone hill known as Mission Mountain, about 1½ miles southwest from Baptist post-office, on Kansas City, Pittsburg and Gulf Railroad. All timber was cut from south end of hill with the exception of one tree, which was used for signal. From point 64.29 chains east on line between secs. 13 and 24, T. 18 N., R. 25 E., station may be reached by going due south 3.51 chains.

Station mark: Lone signal tree.

[Latitude, 36° 01′ 51.57″. Longitude, 94° 35′ 10.55″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Spade	33 24 08.59	213 19 54.66	4.2945621
Kansas	137 13 41.87	317 05 38.30	4.4794358
Decatur	201 09 43.12	21 14 22.39	4.5146056

DECATUR, BENTON COUNTY, ARKANSAS.

On a timbered hill on west side and about one-fourth mile distant from Kansas City, Pittsburg and Gulf Railroad, at point about 4 miles south from town of Decatur. Theodolite elevated 40 feet.

Station mark: A stone post, 24 by 7 by 7 inches, placed 22 inches in the ground, with copper bolt sunk in center of top.

[Latitude, 36° 18′ 20.83″. Longitude, 94° 27′ 17.33″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Baptist	21 14 22.39	201 09 43.12	4.5146056
Kansas	75 33 45.91	255 21 00.82	4.5231238
Round Spring	104 01 35.00	283 46 25.04	4.5959206

KANSAS, CHEROKEE NATION.

On highest point of flat timbered ridge about 2 miles northwest from Kansas post-office. A local road running northwest passes 100 yards west of station. From point 56.70 chains on line N. 0° 01′ W. between secs. 11 and 12, T. 20 N., R. 23 E., station may be reached by going due east 175 links. Theodolite elevated 40 feet.

Station mark: A stone post, 24 by 8 by 8 inches placed 22 inches in the ground, with copper bolt marked $\frac{\text{U. S.}}{\text{G. S.}}$ sunk in center of top.

[Latitude, 36° 13′ 49.10″. Longitude, 94° 48′ 50.68″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Spade	345 50 55.29	165 54 43.46	4.5995950
Salina	69 06 09.42	249 58 38.63	4.3072366
Baptist	317 05 38.30	137 13 41.87	4.4794358
Decatur	255 21 00.82	75 33 45.91	4.5231238
Round Spring	161 20 08.78	341 17 45.50	4.2751402
Spavinaw	118 08 16.98	298 59 10.94	4.4206278

ROUND SPRING, CHEROKEE NATION.

On flat timbered ridge about 2 miles southeast from Round Spring, a well-known point on road between Spavinaw post-office and Southwest City, Missouri. From the corner common to secs. 7, 8, 17, and 18, T. 22 N., R. 23 E., station may be reached by going due south 943 feet, thence S. 48° 15′ W. 522 feet. Theodolite elevated 62 feet.

Station mark: A stone post, 24 by 7 by 7 inches placed 22 inches in the ground, with copper bolt sunk in center of top.

[Latitude, 36° 23′ 28.20″. Longitude, 94° 52′ 52.64″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Spavinaw	73 28 10.32	253 21 26.69	4.2481093
Harman	148 48 33.99	328 43 51.88	4.3576162
Decatur	283 46 25.04	104 01 35.00	4.5959206
Kansas	341 17 45.50	161 20 08.78	4.2751402
Whitewater	240 33 44.43	60 40 36.41	4.2972881
Salina	27 44 59.35	207 39 50.86	4.4469067

SPAVINAW, CHEROKEE NATION.

On highest point of rolling timbered hills, about 4 miles south from Spavinaw post-office. Road from Salina to Spavinaw passes about three-fourths of a mile west from station at point 4 miles from latter. From point 70 chains on line 0° 02′ W. between secs. 32 and 33, T. 22 N., R. 21 E., station may be reached by going S. 63° E. 33.98 chains. Theodolite elevated 36 feet.

Station mark: A stone post, 24 by 7 by 7 inches, placed 22 inches in the ground, with copper bolt sunk in center of top.

[Latitude, 36° 20′ 44.23″. Longitude, 95° 04′ 13.32″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Salina	348 34 55.09	168 36 29.33	4.3035865
Dog Creek	99 46 58.33	279 34 11.68	4.5144608
Wills	141 23 35.83	321 15 04.38	4.5350913
Harman	191 48 02.75	11 50 05.26	4.3991109
Round Spring	253 21 26.69	73 28 10.32	4.2481093
Kansas	298 59 10.94	118 08 16.98	4.4206278
Corbett	66 55 52.51	246 41 34.31	4.5953074

CORBETT, CHEROKEE NATION.

On high prairie hill about 8 miles west from Choteau, a town on Missouri, Kansas, and Texas Railway. The corner common to secs. 14, 15, 22, and 23, T. 20 N., R. 17 E., may be reached from station by going N. 72° 46′ W. 7.08 chains.

Station mark: A stone, post 25 by 7 by 7 inches, placed 22 inches in the ground, with copper bolt marked $\frac{\text{U. S.}}{\text{G. S.}}$ sunk in center of top.

[Latitude, 36° 12′ 21.12″. Longitude, 95° 28′ 23.78″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Salina	275 50 54.04	96 06 44.50	4.6068569
Grand	327 46 03.56	147 55 54.08	4.6743218
Spavinaw	246 41 34.31	66 55 52.51	4.5953074
Dog Creek	190 35 36.48	10 37 09.80	4.3297503
McGinnis	121 10 15.32	301 01 44.48	4.4010233
Merchant	9 13 03.50	189 12 37.68	3.8340395
Barber	350 25 43.32	170 27 26.89	4.4231780
Weer	62 04 38.55	241 53 34.36	4.5037586

DOG CREEK, CHEROKEE NATION.

On highest point of timbered ridge at the head of Dog Creek, about 3 miles northwest from Pryor Creek, a town on Missouri, Kansas and Texas Railway. Road from Pryor Creek to Chelsea passes east of and near station. From line east between secs. 7 and 18, T. 22 N., R. 18 E., at 24.56 chains, station bears N. 13° 16′ W., 4.15 chains distant. Theodolite elevated 40 feet.

Station mark: A stone post, 25 by 8 by 8 inches, set 23 inches in the ground, with copper bolt marked $\frac{\text{U. S.}}{\text{G. S.}}$ sunk in center of top.

[Latitude, 36° 23′ 42.51″. Longitude, 95° 25′ 46.15″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Salina	304 42 34.65	124 56 53.98	4.6449413
Corbett	10 37 09.80	190 35 36.48	4.3297503
Harman	242 50 31.73	63 05 22.97	4.6221325
Wills	206 47 55.03	26 52 12.12	4.3772365
Spavinaw	279 34 11.68	99 46 58.33	4.5144608
Nowata	141 40 22.52	321 30 13.09	4.6125788
McGinnis	72 38 51.29	252 28 45.85	4.4263426
Weer	41 48 22.82	221 35 43.95	4.6830193

WILLS, CHEROKEE NATION.

On highest point of timbered ridge about 4 miles northeast from Catale, a post-office on St. Louis and San Francisco Railroad, and about 3 miles southwest from Mr. Grayson Wills's residence. Railroad passes very near station. Station is 21.10 chains north of corner between secs. 5 and 6, T. 24 N., R. 19 E. Theodolite elevated 36 feet.

Station mark: A stone post, 24 by 8 by 8 inches, placed 22 inches in the ground, with copper bolt marked $\frac{\text{U. S.}}{\text{G. S.}}$ sunk in center of top.

[Latitude, 36° 35′ 12.54″. Longitude, 95° 18′ 33.85″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Spavinaw	321 15 04.38	141 23 35.83	4.5350913
Dog Creek	26 52 12.12	206 47 55.03	4.3772365
Harman	274 42 53.41	94 53 29.06	4.4251143
Bluejacket	216 05 24.85	36 12 06.89	4.4521138
Blue Mound	164 46 10.76	344 43 37.05	4.3851818
Nowata	106 48 23.19	286 33 54.42	4.5770317

HARMAN, CHEROKEE NATION.

On prairie end of a timbered ridge about 10 miles southeast of Vinita. Road from Vinita to Southwest City, Missouri, passes near station at point 10 miles from former. From the corner common to secs. 7, 12, 13, and 18, T. 24 N., R. 21 E., station may be reached by going west between secs. 12 and 13 28.85 chains, thence S. 44° W. 13.25 chains. Theodolite elevated 15 feet.

Station mark: A stone post, 24 by 8 by 8 inches, placed 22 inches in the ground, with copper bolt marked $\frac{\text{U. S.}}{\text{G. S.}}$ sunk in center of top.

[Latitude, 36° 34′ 00.25″. Longitude, 95° 00′ 47.15″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Spavinaw	11 50 05.26	191 48 02.75	4.3991109
Wills	94 53 29.06	274 42 53.41	4.4251143
Round Spring	328 43 51.88	148 48 33.99	4.3576162
Seneca	243 16 13.46	63 28 22.72	4.5310247
Potato Hill	186 23 44.04	6 25 17.68	4.5418089
Bluejacket	158 44 49.93	338 40 54.68	4.4303314
Whitewater	288 27 17.83	108 38 53.07	4.4865362
Wasson	166 02 37.50	345 58 31.23	4.6256566

WHITEWATER, CHEROKEE NATION.

On flat timbered ridge on south side and 1 mile distant from Whitewater Creek at point 4 miles west from Arkansas line. Road from Spavinaw to Southwest City, Missouri, passes 1 mile south from station at point 6 or 7 miles from latter. From the corner common to secs. 7, 12, 13, and 18, T. 23 N., R. 24 E., station bears S. 56° 02′ W., 31.42 chains distant. Theodolite elevated 40 feet.

Station mark: A stone post, 24 by 7 by 7 inches, placed 22 inches in the ground, with copper bolt marked $\frac{\text{U. S.}}{\text{G. S.}}$ sunk in center of top.

[Latitude, 36° 28′ 43.81″. Longitude, 94° 41′ 18.96″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Round Spring	60 40 36.41	240 33 44.43	4.2972881
Harman	108 38 53.07	288 27 17.83	4.4865362
Seneca	183 04 02.77	3 04 34.91	4.3981625

SENECA, SENECA NATION.

On highest point of rolling timbered hills in T. 26 N., R. 24 E., about 6 miles northwest from Tiff City, Missouri. Road from Grove to Seneca, Missouri, passes east from station at point 10 or 11 miles from Seneca. Theodolite elevated 40 feet.

Station mark: A stone post, 24 by 7 by 7 inches, placed 22 inches in the ground, with copper bolt marked $\frac{\text{U. S.}}{\text{G. S.}}$ sunk in center of top.

[Latitude, 36° 42′ 14.11″. Longitude, 94° 40′ 25.03″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Whitewater	3 04 34.91	183 04 02.77	4.3981625
Harman	63 28 22.72	243 16 13.46	4.5310247
Bluejacket	103 58 24.72	283 42 17.89	4.6157967
Wasson	122 35 52.45	302 19 33.36	4.6811412
Potato Hill	126 20 57.25	306 10 19.12	4.5153808
Edwards	158 12 15.96	338 06 52.76	4.5548967
Peoria	190 41 33.33	10 43 14.93	4.3546688

PEORIA, PEORIA NATION (not occupied).

On a flat timbered ridge in T. 28 N., R. 25 E., 1 mile west from Missouri line, at point 6 miles north from Seneca, Missouri.

Station mark: A stone post, 25 by 7 by 7 inches, placed 22 inches in the ground, with copper bolt marked $\frac{\text{U. S.}}{\text{G. S.}}$ sunk in center of top.

[Latitude, 36° 54′ 15.44″. Longitude, 94° 37′ 35.44″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Seneca	10 43 14.93	190 41 33.33	4.3546688
Edwards	122 20 26.60	302 13 20.69	4.3166521

POTATO HILL, CHEROKEE NATION.

On prairie, at a point locally known as Potato Hill. Road from Bluejacket to Miami passes southeast and very near station, at point 10 or 11 miles from former. From line east between secs. 29 and 32, T. 28 N., R. 22 E., at 48.26 chains from corner, station bears due north, 24.35 chains distant.

Station mark: A rock monument 6 feet high and 5 or 6 feet in diameter at base.

[Latitude, 36° 52′ 42.74″. Longitude, 94° 58′ 10.54″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Seneca	306 10 19.12	126 20 57.25	4.5153808
Harman	6 25 17.68	186 23 44.04	4.5418089
Edwards	223 02 51.73	43 08 08.24	4.2804780
Wasson	114 26 36.83	294 20 55.61	4.1888109
Bluejacket	55 10 50.11	235 05 20.12	4.2207046

WASSON, CHEROKEE NATION.

On high prairie ridge about 3 miles west from Wasson, a switch on Missouri, Kansas and Texas Railway. From line N. 0° 1′ W. between secs. 1 and 2, T. 28 N., R. 20 E., at 20.73 chains, station bears due west, 11.70 chains distant.

Station mark: A stone post, 25 by 7 by 7 inches, placed 22 inches in the ground, with copper bolt marked $\frac{\text{U. S.}}{\text{G. S.}}$ sunk in center of top.

[Latitude, 36° 56′ 09.70″. Longitude, 95° 07′ 38.75″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Edwards	254 19 49.12	74 30 47.56	4.4489361
Potato Hill	294 20 55.61	114 26 36.83	4.1888109
Bluejacket	358 24 33.48	178 24 44.15	4.2010781
Harman	345 58 31.23	166 02 37.50	4.6256566
Seneca	302 19 33.36	122 35 52.45	4.6811412

EDWARDS, CHEROKEE COUNTY, KANSAS.

On a prairie hill, locally known as Blue Mound, one-fourth mile north from line between Kansas and Quapaw Nation, Indian Territory, at point about 6 miles west of Baxter Springs, Kansas. Land is owned by Mr. Edwards.

Station mark: A stone post, 24 by 7 by 7 inches, placed 22 inches in the ground, with copper bolt sunk in center of top.

[Latitude, 37° 00′ 14.64″. Longitude, 94° 49′ 23.90″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Peoria	302 13 20.69	122 20 26.60	4.3166521
Seneca	338 06 52.76	158 12 15.96	4.5548967
Potato Hill	43 08 08.24	223 02 51.73	4.2804780
Bluejacket	48 47 01.38	228 36 14.68	4.5502216
Wasson	74 30 47.56	254 19 49.12	4.4489361

BLUEJACKET, CHEROKEE NATION.

On highest point of flat-topped timbered mountain or hill, locally known as Bluejacket Mountain. Hill is about 3 miles a little south of west from Bluejacket, a town on the Missouri, Kansas and Texas Railway. From line north between secs. 25 and 26, T. 27 N., R. 20 E. at 53.50 chains, station bears S. 25° 20′ E., 23.45 chains distant. Theodolite elevated 55 feet.

Station mark: A stone post, 25 by 8 by 8 inches, placed 22 inches in the ground, with copper bolt marked U. S. + G. S. sunk in center of top.

[Latitude, 36° 47′ 34.48″. Longitude, 95° 07′ 20.96″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Wasson	178 24 44.15	358 24 33.48	4.2010781
Potato Hill	235 05 20.12	55 10 50.11	4.2207046
Wills	36 12 06.89	216 05 24.85	4.4521138
Blue Mound	91 26 48.76	271 17 31.65	4.3629821
Harman	338 40 54.68	158 44 49.93	4.4303314
Edwards	228 36 14.68	48 47 01.38	4.5502216
Seneca	283 42 17.89	103 58 24.72	4.6157967

BLUE MOUND, CHEROKEE NATION.

On the highest of several prairie hills, about 3 miles southwest from Miles post-office. The hill is locally known as Blue Mound. From corner common to secs. 21, 22, 27, and 28, T. 27 N., R. 18 E., station bears S. 47° W., and from corner common to secs. 20, 21, 28, and 29 station bears S. 74° 55′ E.

Station mark: A tree wired up.

[Latitude, 36° 47′ 52.36″. Longitude, 95° 22′ 51.09″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Bluejacket	271 17 31.65	91 26 48.76	4.3629821
Wills	344 43 37.05	164 46 10.76	4.3851818
Nowata	67 10 16.62	246 58 19.58	4.5090643
California	89 41 31.72	269 27 52.70	4.5302085
Timber Hill	117 20 59.76	297 08 25.37	4.5444066

TIMBER HILL, CHEROKEE NATION.

On timber-covered hill locally known as Timber Hill. Road from Barnesville to Coffeyville, Kansas, passes west and very near signal at Point 9 miles from latter. From the corner of Ts. 27 and 28 N., Rs. 14 and 15 E., station may be reached by running east on seventh standard parallel 7.42 chains, thence south 32 links. Theodolite elevated 35 feet.

Station mark: A stone post, 24 by 8 by 8 inches, placed 21 inches in the ground, with copper bolt marked $\frac{\text{U. S.}}{\text{G. S.}}$ + sunk in center of top.

[Latitude, 36° 56′ 32.56″. Longitude, 95° 43′ 48.46″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Blue Mound	297 08 25.37	117 20 59.76	4.5444066
Nowata	357 05 14.19	177 05 49.33	4.4571525
Panther	40 50 41.73	220 39 58.27	4.6105159
Caney	99 55 15.52	279 45 49.47	4.3736097
California	9 30 46.14	189 29 40.11	4.2177888

CALIFORNIA, CHEROKEE NATION.

On a high and rather flat prairie ridge, about 10 miles northwest of Nowata, a town on the St. Louis, Iron Mountain and Southern Railway. The corner common to secs. 25, 26, 35, and 36, T. 27 N., R. 14 E., may be reached from station by going S. 16° 03′ W. 52.78 chains to east and west line, thence west 40.015 chains.

Station mark: A stone post, 24 by 8 by 8 inches, placed 22 inches in the ground, with a copper bolt marked $\frac{\text{U. S.}}{\text{G. S.}}$ sunk in center of top.

[Latitude, 36° 47′ 44.27″. Longitude, 95° 45′ 38.47″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Panther	58 39 48.52	238 30 11.99	4.4476258
Caney	134 42 12.40	314 33 53.38	4.4613481
Timber Hill	189 29 40.11	9 30 46.14	4.2177888
Nowata	341 14 06.14	161 15 47.06	4.1146470
Blue Mound	269 27 52.70	89 41 31.72	4.5302085

NOWATA, CHEROKEE NATION.

On high and rather flat prairie ridge, about 4 miles a little south west of Nowata. Road from Nowata to Ringo passes 2 miles sou[illegible] east of station at point 5 miles from former. From quarter cor[illegible] between secs. 4 and 33, Ts. 25 and 26 N., R. 15 E., station be[illegible] west, 16.89 chains distant.

Station mark: A stone post, 24 by 7 by 7 inches, placed 22 inches in the ground, with copper bolt marked $\frac{\text{U. S.}}{\text{G. S.}}$ sunk in center of top.

[Latitude, 36° 41′ 04.27″. Longitude, 95° 42′ 49.76″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Blue Mound	246 58 19.58	67 10 16.62	4.5090643
Wills	286 33 54.42	106 48 23.19	4.5770317
Timber Hill	177 05 49.33	357 05 14.19	4.4571525
Panther	85 27 27.81	265 16 11.27	4.4505532
Skiatook	49 03 24.72	228 50 58.50	4.6160005
McGinnis	359 55 04.31	179 55 05.68	4.6032387
California	161 15 47.06	341 14 06.14	4.1146470
Dog Creek	321 30 13.09	141 40 22.52	4.6125788

M'GINNIS, CHEROKEE NATION.

In T. 21 N., R. 15 E., on highest point of a high ridge with scattering timber on it. This ridge extends along the west side of the Verdigris River, about 7 miles west from Claremore, a town on the St. Louis and San Francisco Railroad. Road from Claremore to Eli passes south of and 1 mile from the station. Theodolite elevated 34 feet.

Station mark: A stone post, 24 by 7 by 7 inches, placed 22 inches in the ground, with copper bolt marked $\frac{\text{U. S.}}{\text{G. S.}}$ sunk in center of top.

[Latitude, 36° 19′ 23.05″. Longitude, 95° 42′ 47.45″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Skiatook	112 38 48.35	292 26 23.94	4.5297992
Nowata	179 55 05.68	359 55 04.31	4.6032387
Weer	13 12 56.02	193 10 20.92	4.4585858
Tulsa	67 00 44.14	246 48 50.98	4.5147481
Panther	143 20 26.02	323 09 10.98	4.6740564
Merchant	313 53 07.78	134 01 12.44	4.4539608
Corbett	301 01 44.48	121 10 15.32	4.4010233
Dog Creek	252 28 45.85	72 38 51.29	4.4263426

TULSA, OSAGE NATION, OKLAHOMA TERRITORY.

On a very prominent prairie peak, about 5 miles northwest of Tulsa, a town on the St. Louis and San Francisco Railroad. Road from Tulsa to Cleveland, Arkansas, passes very near station. The corner common to secs. 7, 8, 17, and 18, T. 20 N., R. 12 E., may be reached

from station by going due west 29.39 chains to north-south line, thence north 50.61 chains.

Station mark: A stone post, 24 by 7 by 7 inches, placed 22 inches in the ground, with copper bolt sunk in center of top.

[Latitude, 36° 12′ 26.84″. Longitude, 96° 02′ 53.08″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Skiatook	177 16 22.22	357 15 52.98	4.4123352
McGinnis	246 48 50.98	67 00 44.14	4.5147481
Weer	302 39 44.40	122 49 00.53	4.4476239
Prairie	357 27 52.19	177 28 19.97	4.4267742

SKIATOOK, OSAGE NATION, OKLAHOMA TERRITORY.

On a small knoll on highest part of timbered ridge about 6 miles northwest from Skiatook, a post-office in the Cherokee Nation, Indian Territory. Road between Skiatook and Pawhuska passes about 300 yards north of station at point 6 miles from latter. The corner common to secs. 29, 30, 31, and 32, T. 23 N., R. 12 E., may be reached from station by going due east 60.56 chains to north-south line, thence south 32.79 chains. Theodolite elevated 40 feet.

Station mark: A stone post, 24 by 8 by 8 inches, placed 22 inches in the ground, with copper bolt marked $\frac{\text{U. S.}}{\text{G. S.}}$ sunk in center of top.

[Latitude, 36° 26′ 24.31″. Longitude, 96° 03′ 42.45″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Panther	186 50 15.58	6 51 27.02	4.3983118
Nowata	228 50 58.50	49 03 24.72	4.6160005
McGinnis	292 26 23.94	112 38 48.35	4.5297992
Tulsa	357 15 52.98	177 16 22.22	4.4123352
Monument	56 03 35.76	235 53 56.03	4.4684714
Tres Mounds	100 50 57.57	280 41 10.74	4.3984362
Pawhuska	146 13 44.48	326 06 03.07	4.5388769

PANTHER, OSAGE NATION, OKLAHOMA TERRITORY.

On highest part of ridge, with scattering timber on it, at the head of Panther Creek. Road between Bartlesville and Hominy, Indian Territory, passes 100 yards north of station at point about 8 miles from former. The corner common to secs. 4, 5, 8, and 9, T. 25 N.,

R. 12 E., may be reached by going due east 17.23 chains to north-south line, thence north 9.85 chains. Theodolite elevated 40 feet.

Station mark: A stone post, 24 by 7 by 7 inches, placed 22 inches in the ground, with copper bolt marked $\frac{\text{U. S.}}{\text{G. S.}}$ sunk in center of top.

[Latitude, 36° 39′ 50.27″. Longitude, 96° 01′ 42.50″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Timber Hill	220 39 58.27	40 50 41.73	4.6105159
Nowata	265 16 11.27	85 27 27.81	4.4505532
Skiatook	6 51 27.02	186 50 15.58	4.3983118
California	238 30 11.99	58 39 48.52	4.4476258
McGinnis	323 09 10.98	143 20 26.02	4.6740564
Pawhuska	99 59 43.44	279 50 49.16	4.3530341
Spring Creek	139 35 51.39	319 27 51.99	4.4857711

CANEY, CHEROKEE NATION.

On highest point of prairie ridge about 3½ miles southwest of Caney, Kansas. Road between Caney and Pawhuska, Oklahoma Territory, passes about 200 yards east of station at point 3½ miles from former. The corner common to secs. 22, 23, 26, and 27, T. 29 N., R. 12 E., may be reached from station by going S. 86° 30′ E. 32.88 chains to north-south line, thence south 40 chains.

Station mark: A rock about 4 feet square, with a copper bolt marked $\frac{\text{U. S.}}{\text{G. S.}}$ sunk into it.

[Latitude, 36° 58′ 43.64″. Longitude, 95° 59′ 29.83″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Timber Hill	279 45 49.47	99 55 15.52	4.3736097
Panther	5 23 15.45	185 21 55.94	4.5451946
California	314 33 53.38	134 42 12.40	4.4613481
Spring Creek	63 18 40.66	243 09 19.79	4.4129408
Artillery	88 46 57.15	268 38 08.64	4.3372276

ARTILLERY, OSAGE NATION, OKLAHOMA TERRITORY.

On highest part of hill locally known as Artillery Mountain, about 3½ miles southeast from Elgin, Kansas.

Station mark: A stone post, 24 by 7 by 7 inches, placed 22 inches in the ground, with copper bolt marked $\frac{\text{U. S.}}{\text{G. S.}}$ sunk in center of top.

[Latitude, 36° 58′ 27.75″. Longitude, 96° 14′ 08.50″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Caney	268 38 08.64	88 46 57.15	4.3372276
Spring Creek	6 56 31.64	186 55 58.67	4.0510469

SPRING CREEK, OSAGE NATION, OKLAHOMA TERRITORY.

On the highest part of a flat, timbered ridge (no timber within 100 yards of station). Road between Elgin, Kansas, and Pawhuska, Oklahoma Territory, passes about 1 mile west from station at a point 12 miles from former. Theodolite elevated 20 feet.

Station mark: A stone post, 24 by 7 by 7 inches, placed 22 inches in the ground, with copper bolt marked $\frac{\text{U. S.}}{\text{G. S.}}$ sunk in center of top.

[Latitude, 36° 52′ 25.56″. Longitude, 96° 15′ 03.39″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Artillery	186 55 58.67	6 56 31.64	4.0510469
Caney	243 09 19.79	63 18 40.66	4.4129408
Panther	319 27 51.99	139 35 51.39	4.4857711
Pawhuska	6 49 26.30	186 48 30.30	4.2908297
Flint	60 31 16.82	240 20 22.61	4.4930920

PAWHUSKA, OSAGE NATION, OKLAHOMA TERRITORY.

On high prairie hill about 4 miles a little north of east from Pawhuska, Oklahoma Territory. Road from Pawhuska, Oklahoma Territory, to Bartleville, Indian Territory, passes the foot of mountain on south side.

Station mark: A stone post, 25 by 8 by 8 inches, placed 22 inches in the ground, with copper bolt marked $\frac{\text{U. S.}}{\text{G. S.}}$ sunk in center of top.

[Latitude, 36° 41′ 56.28″. Longitude, 96° 16′ 36.90″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Spring Creek	186 48 30.30	6 49 36.30	4.2908297
Panther	279 50 49.16	99 59 43.44	4.3530341
Skiatook	326 06 03.07	146 13 44.48	4.5388769
Tres Mounds	12 26 06.12	192 23 59.13	4.3914142
Flint	99 20 22.52	279 10 25.56	4.3997971

FLINT, OSAGE NATION, OKLAHOMA TERRITORY.

On highest point on long range of prairie hills locally known as the Flint Hills. Road running west from Pawhuska into the Kaw Reservation passes about 1 mile south from station at point where it crosses the Flint Hills (about 14 miles from Pawhuska).

Station mark: A stone post, 25 by 7 by 7 inches, placed 22 inches in the ground, with copper bolt marked $\frac{\text{U. S.}}{\text{G. S.}}$ sunk in center of top.

[Latitude, 36° 44′ 07.30″. Longitude, 96° 33′ 15.40″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Spring Creek	240 20 22.61	60 31 16.82	4.4930920
Pawhuska	279 10 25.56	99 20 22.52	4.3997971
Tres Mounds	325 08 17.04	145 16 05.45	4.5341085

TRES MOUNDS, OSAGE NATION, OKLAHOMA TERRITORY.

On the highest of three lone prairie hills locally known as Tres Mounds, about 3 miles north from Hominy post-office.

Station mark: A rock about 18 inches long, with $\frac{\text{U. S.}}{\text{G. S.}}$ cut on it. Rock about 2 inches above ground.

[Latitude, 36° 28′ 56.02″. Longitude, 96° 20′ 09.93″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Flint	145 16 05.45	325 08 17.04	4.5341085
Pawhuska	192 23 59.13	12 26 06.12	4.3914142
Skiatook	280 41 10.74	100 50 57.57	4.3984362
Monument	359 20 24.17	179 20 29.95	4.3249252

MONUMENT, OSAGE NATION, OKLAHOMA TERRITORY.

On a prairie hill 10 miles south of Hominy post-office. Road between Hominy and Tulsa, Indian Territory, goes within 1 mile of hill at point about 9 miles from Hominy, and then bears southeast. A "dim right hand" at this point passes near and east of the foot of the hill.

Station mark: A rock monument 7 feet high.

[Latitude, 36° 17′ 30.50″. Longitude, 96° 20′ 00.18″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Tres Mounds	179 20 29.95	359 20 24.17	4.3249252
Skiatook	235 53 56.03	56 03 35.76	4.4684714

STILWELL, CHEROKEE NATION (not occupied).

On a high, timbered peak about 6 miles south from Stilwell. A higher, flat-topped, timbered mountain lies northeast from peak. From point 26.94 chains north from corner common to secs. 26, 27, 34, and 35, T. 15 N., R. 25 E., station bears east 9.01 chains distant.

Station mark: Lone signal tree.

[Latitude, 35° 44′ 41.06″. Longitude, 94° 37′ 39.08″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Choate	63 22 56.29	243 16 30.33	4.2695959
Spade	155 02 57.29	335 00 11.15	4.2274522
Baptist	186 40 45.43	6 42 08.85	4.5048461

SALLISAW, CHEROKEE NATION.

On highest point on timbered ridge about 4 miles south from town of Sallisaw, on Kansas City, Pittsburg and Gulf Railroad and St. Louis, Iron Mountain and Southern Railway, about 2½ miles northeast from Brent post-office. The corner common to secs. 21, 22, 27, and 28, T. 11 N., R. 24 E., may be reached from station by going due north 3.23 chains to east-west line between secs. 21 and 28, thence east 38.43 chains. Theodolite elevated 34 feet.

Station mark: A stone post, 24 by 8 by 8 inches, placed 22 inches in the ground, with copper bolt marked $\frac{\text{U. S.}}{\text{G. S.}}$ sunk in center of top.

[Latitude, 35° 24′ 18.13″. Longitude, 94° 46′ 08.22″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Nebo	103 38 51.05	283 17 43.13	4.7532830
Choate	172 33 17.87	352 31 10.02	4.4710443
Redoak	41 26 25.25	221 12 37.16	4.7403246

WINDING STAIR, CHOCTAW NATION.

On the highest point of the Winding Stair Mountains, locally well known by the above name, reached from Talihina, a town on the main line of the St. Louis and San Francisco Railroad. The corner to secs. 32 and 33, T. 4 N., R. 23 E., may be reached from station by going due west 22.15 chains to north-south line, thence south 44.24 chains.

Station mark: Stump of tree 3½ feet high, with rocks piled around it.

[Latitude, 34° 46′ 33.37″. Longitude, 94° 53′ 49.05″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Dexter	68 01 12.78	247 43 32.00	4.7094046
Redoak	139 05 31.03	318 56 13.09	4.5768480
Cavanal	211 18 39.19	31 26 09.15	4.5834269
Poteau	245 59 43.58	66 13 40.12	4.6093287
Polecat	297 08 53.13	117 23 45.61	4.6524261
Kiamichi	334 39 24.31	154 42 19.59	4.2630071

DEXTER, CHOCTAW NATION.

About 4 miles a little north of west from Dexter post-office, on the St. Louis and San Francisco Railroad. The quarter corner between secs. 28 and 23, T. 2 N., R. 18 E., is 2,473 feet north and 938 feet west of station. Theodolite elevated on a stump cut off 18 feet above ground.

Station mark: Signal tree.

[Latitude, 34° 36′ 07.32″. Longitude, 95° 24′ 52.95″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Hewitt	92 08 49.08	271 58 10.85	4.4571430
Hartshorne	146 08 49.37	326 03 29.37	4.4091583
Redoak	205 13 54.57	25 22 22.06	4.7230759
Winding Stair	247 43 32.00	68 01 12.78	4.7094046
Kiamichi	267 00 22.13	87 20 55.81	4.7434931
Thunderbolt	310 37 44.32	130 50 35.53	4.6618115
Kosoma	40 10 38.45	220 03 43.28	4.4626567

KIAMICHI, CHOCTAW NATION.

On highest point on ridge locally known as the Kiamichi Mountains. The Talihina and Mena (Arkansas) road passes 5 or 6 miles north of station at point 22 miles from Talihina (George Field's residence).

From Mr. Field's a trail to Smithville crosses mountains at point 3½ or 4 miles east from station. Fair traveling on horseback from this point up ridge to station. From point 23.15 chains north on line between secs. 19 and 20, T. 2 N., R. 24 E., station bears S. 76° E. 14.77 chains distant.

Station mark: A rock set in ground with U. S. G. S. cut in it.

[Latitude, 34° 37′ 35.85″. Longitude, 94° 48′ 42.15″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Dexter	87 20 55.81	267 00 22.13	4.7434931
Winding Stair	154 42 19.59	334 39 24.31	4.2630071
Polecat	277 02 01.42	97 13 57.35	4.5101014
Hardscrabble	330 09 55.23	150 18 45.73	4.6834888
Thunderbolt	32 20 44.63	212 13 06.61	4.5872205

POLECAT, CHOCTAW NATION.

On the highest part of point locally known as Polecat Peak. The Talihina and Mena road passes about 4 miles north of the station at point where road crosses the boundary line between Arkansas and the Indian Territory. Mr. Jack Conley's residence is near this point on the Arkansas side. A trail leads from his place to the station. Station is 21.53 chains south and 13.77 chains east of corner to secs. 3, 4, 33, and 34, Ts. 1 and 2 N., R. 27 E.

Station mark: An oak tree with U. S. G. S. cut on it. All other trees cut from summit of hill.

[Latitude, 34° 35′ 25.42″. Longitude, 94° 27′ 40.63″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Hardscrabble	12 17 35.04	192 14 32.78	4.5882821
Thunderbolt	61 40 42.89	241 21 11.80	4.7788619
Kiamichi	97 13 57.35	277 02 01.42	4.5101014
Winding Stair	117 23 45.61	297 08 53.13	4.6524261

BASE LINE, CHOCTAW NATION (not occupied).

On a narrow rock ridge in southwest corner of sec. 31, T. 1 N., R. 24 E. To reach station take road running northwest from Smithville post-office until standard parallel is crossed, thence west up ridge till station is reached. From point 17.15 chains north, between secs. 31 and 36, on range line Rs. 23 and 24 E., T. 1 N., station may be reached by going east 7.61 chains.

Station mark: White oak signal tree.

[Latitude, 34° 30′ 37.81″. Longitude, 94° 49′ 48.38″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Thunderbolt	43 47 32.70	223 40 33.36	4.4377864
Hardscrabble	318 23 41.50	138 33 09.17	4.5881731

THUNDERBOLT, CHOCTAW NATION.

In the southwest corner of T. 2 S., R. 22 E., on highest point in the vicinity. A rough road from Noel's store to Mount Zion passes about 3 miles north from station at point 6 miles from latter. From corner of Ts. 2 and 3 N., Rs. 21 and 22 E., station may be reached by going east 44.13 chains on line between secs. 6 and 31, thence north 6.25 chains. Theodolite elevated 24 feet.

Station mark: A pine tree about 45 feet high with a copper bolt marked $\frac{\text{U. S.}}{\text{G. S.}}$ set in it about 4 feet above ground. All limbs were cut from tree except a small bunch left at the top for signal.

[Latitude, 34° 19′ 55.23″. Longitude, 95° 02′ 09.82″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Dexter	130 50 35.53	310 37 44.32	4.6618115
Kiamichi	212 13 06.61	32 20 44.63	4.5872205
Base line	223 40 33.36	43 47 32.70	4.4377864
Polecat	241 21 11.80	61 40 42.89	4.7788619
Hardscrabble	281 30 08.06	101 46 32.38	4.6591764
Garvin	346 04 42.70	166 08 33.69	4.6427670
Noel	40 06 55.36	220 00 06.08	4.4613892

HARDSCRABBLE, CHOCTAW NATION.

On the highest of several timbered hills. All timber was cut from summit of hill except an oak tree, which was left for signal. There is a small farm rented by Mr. Jacobs about three-fourths of a mile south from hill. Road from Hatton Gap, Arkansas, to Eagletown, Indian Territory, passes within 3 miles of station at point where road to Jacobs's farm leaves main road. From quarter corner between secs. 26 and 35, T. 3 S., R. 26 E., station bears S. 9° W., 57 chains distant.

Station mark: Copper bolt set in the lone oak signal tree.

[Latitude, 34° 14′ 56.52″. Longitude, 94° 33′ 03.07″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Garvin	45 46 31.78	225 34 03.05	4.6799561
Thunderbolt	101 46 32.38	281 30 08.06	4.6591764
Base line	138 33 09.17	318 23 41.50	4.5881731
Kiamichi	150 18 45.73	330 09 55.23	4.6834888
Polecat	192 14 32.78	12 17 35.04	4.5882821

GARVIN, CHOCTAW NATION.

In T. 7 S., R. 23 E., on highest point of flat timbered ridge about 1 mile north from Garvin post-office. Road running north from Garvin passes about 40 yards west of station at a point 1 mile from former. Theodolite elevated 20 feet.

Station mark: A copper bolt set in a post-oak tree.

[Latitude, 33° 56′ 51.14″. Longitude, 94° 55′ 18.63″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Noel	125 08 33.15	304 57 55.50	4.5526062
Thunderbolt	166 08 33.69	346 04 42.70	4.6427670
Hardscrabble	225 34 03.05	45 46 31.78	4.6799561

NOEL, CHOCTAW NATION.

On timbered hill about 5 miles southeast from Noel's store, which is in sec. 27, T. 4 S., R. 19 E. Road running southeast from store passes about 1 mile north from station. The highest timber was cut from summit of hill. The corner common to secs. 7, 8, 17, and 18, T. 5 S., R. 20 E., may be reached from station by going due west 21.70 chains to north-south line, thence south 24.45 chains. Theodolite elevated 20 feet.

Station mark: A lone tree.

[Latitude, 34° 07′ 56.53″. Longitude, 95° 14′ 17.77″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Thunderbolt	220 00 06.08	40 06 55.36	4.4613892
Garvin	304 57 55.50	125 08 33.15	4.5526062

KOSOMA, CHOCTAW NATION.

On a bluff about 1½ miles west of the wagon road from Kosoma to Tuskahoma and about 3 miles north of Kosoma. To reach station, take road northward from Kosoma for 2 miles, thence west by road which can be followed to top of ridge on which station is located. The corner common to secs. 3, 4, 9, and 10, T. 2 S., R. 16 E., may be reached from station by going N. 0° 01′ W. 0.01 chain, thence west 18.19 chains.

[Latitude, 34° 24′ 07.20″. Longitude, 95° 37′ 05.90″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Hewitt	156 47 34.00	336 43 52.60	4.4025800
Dexter	220 03 43.28	40 10 38.45	4.4626567

POTEAU, CHOCTAW NATION.

On a high mountain 15 miles south of Cameron station; summit has considerable timber on it. From corner of secs. 5, 6, 7, and 8, T. 5 N., R. 27 E., station bears S. 19.12 chains and W. 17.90 chains.

Station mark: A lone oak tree, trimmed.

[Latitude, 34° 55′ 27.90″. Longitude, 94° 29′ 25.12″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Winding Stair	66 13 40.12	245 59 43.58	4.6093287
Cavanal	133 25 57.21	313 19 28.38	4.3739002
Sugarloaf	190 17 55.18	10 18 41.69	4.0608964
Peak	212 58 14.23	33 02 18.15	4.2966365

SUGARLOAF, CHOCTAW NATION.

On a high and well-known mountain, 7 miles southeast of Cameron station, near the Arkansas line. All timber has been cleared from summit. From the corner of secs. 4 and 5, north boundary T. 6 N., R. 27 E., station may be reached by going south 14.62 chains, thence east 6.25 chains.

Station mark: Copper bolt set in a large flat ledge.

[Latitude, 35° 01′ 35.23″. Longitude, 94° 28′ 03.98″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Poteau	10 18 41.69	190 17 55.18	4.0608964
Cavanal	104 25 23.59	284 18 07.67	4.2979498
Peak	238 45 43.46	58 49 01.09	4.0084853

PEAK, SEBASTIAN COUNTY, ARKANSAS.

On a sharp summit of Sugarloaf Mountain, about 6 miles northeast of the highest summit (Sugarloaf Peak).

Station mark: A rock monument.

[Latitude, 35° 04′ 26.71″. Longitude, 94° 22′ 19.84″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Poteau	33 02 18.15	212 58 14.23	4.2966365
Sugarloaf	58 49 01.09	238 45 43.46	4.0084852
Cavanal	89 21 15.63	269 10 41.71	4.4464401

DEXTER, COOK COUNTY, TEXAS.

On the highest point of flat ridge N. 69° E. and 0.7 mile distant from the town of Dexter and on the south edge of the timber extending east from same town. Theodolite elevated 40 feet.

Station mark: A copper bolt set in a sandstone rock flush with the surface of the ground, from which bears (counting from the south point around to the west) the following trees: A post oak 14 inches in diameter, 33° 35′, distance 31.7 feet; a post oak 14 inches in diameter, 135° 06′, distance 27.8 feet; a post oak 10 inches in diameter, 189° 00′, distance 78.7 feet. Each tree is blazed and marked U. S. G. S. △ B.

[Latitude, 33° 49′ 14.91″. Longitude, 96° 57′ 08.08″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Marietta	131 53 04.24	311 48 32.48	4.2259004
Cliff	224 58 33.06	45 06 10.47	4.4738536
Fink	273 30 48.99	93 38 36.99	4.3358726
Good	294 12 01.76	114 22 11.70	4.4911465
Morman Grove	320 23 13.12	140 31 41.84	4.5693849
County line	5 07 34.25	185 07 12.35	4.0551508
Provence	172 35 41.10	352 33 59.26	4.5589067

COUNTY LINE, COOK COUNTY, *TEXAS.*

On the summit of the eastern one of two timbered hills in Cook County, Texas. It bears N. 37° W., 5.4 miles from the town of Whitesboro in Grayson County, and S. 86° W., 1 mile from County Line post-office. Theodolite elevated 40 feet.

Station mark: A copper bolt set in a sandstone rock, from which bears (counting from the south point around to the west): A black jack tree 5 inches diameter, 71° 09′, distance 59.7 feet; a post oak tree 7 inches diameter, 151° 54′, distance 40.3 feet; a post oak tree 8 inches diameter, 188° 54′, distance 46.5 feet; a post oak tree 5 inches in diameter, 316° 35′, distance 40.5 feet. Each tree is blazed and marked U. S. G. S. △ B. T.

[Latitude, 33° 43′ 07.86″. Longitude, 96° 57′ 47.48″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Marietta	152 56 34.40	332 52 25.05	4.4032722
Dexter	185 07 12.35	5 07 34.25	4.0551508
Fink	246 12 30.66	66 20 39.94	4.3935107
Good	272 43 05.11	92 53 36.11	4.4670038
Morman Grove	304 59 30.94	125 08 20.82	4.4787932

FINK, GRAYSON COUNTY, TEXAS.

On a timbered hill that bears N. 50° W., distant 4.5 miles from the town of Pottsboro, Grayson County, Texas, and about 100 yards north of the road from Funk post-office to Bounds Ferry on Red River, and distant 2.4 miles westerly from Funk post-office. Theodolite elevated 40 feet.

Station mark: A copper bolt set in a sandstone rock placed flush with the surface of the ground, from which the following trees bear (counting from the south point around to the west): A post oak, 14 inches diameter, 90° 04′, distance 46.5 feet; a post oak, 12 inches diameter, 137° 54′, distance 38.6 feet; a post oak, 16 inches diameter, 259° 12′, distance 18.5 feet; a black-jack, 12 inches diameter, 356° 49′, distance 49.3 feet. Each tree is blazed and marked "U. S. G. S. △ B. T."

[Latitude, 33° 48′ 31.01″. Longitude, 96° 43′ 07.12″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Good	329 53 02.91	149 55 25.45	4.1194420
County line	66 20 39.94	246 12 30.66	4.3935107
Dexter	93 38 36.99	273 30 48.99	4.3358726
Cliff	178 36 32.86	358 36 21.04	4.3500409

GOOD, GRAYSON COUNTY, TEXAS.

On the summit of a flat ridge between Pottsboro and Sherman, bearing S. 17° E., distant 3.8 miles from the town of Pottsboro, and on the premises of the "widow Good," about 50 yards east of the road between Pottsboro and Sherman. Theodolite elevated 20 feet.

Station mark: A copper bolt set in a sandstone rock which is flush with the surface of the ground, from which the southwest corner of widow Good's house bears (counting from the south point around to west) 349° 18′; distance, 142.6 feet.

[Latitude, 33° 42′ 21.29″. Longitude, 96° 38′ 50.59″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
Mormon Grove	16 20 39.89	196 18 59.97	4.2183856
County line	92 53 36.11	272 43 05.11	4.4670038
Dexter	114 22 11.70	294 12 01.76	4.4911465
Fink	149 55 25.45	329 53 02.91	4.1194420
Cliff	168 05 12.03	248 02 37.31	4.5380660

MORMON GROVE, GRAYSON COUNTY, TEXAS.

On the premises of J. D. Hall, 550 feet northeast of Mormon Grove post-office, which is S. 45¼° W., distant 7.18 miles from the courthouse at Sherman. The station is in a cultivated field about 25 yards north of Hall's peach orchard.

Station mark: A copper bolt set in a rock placed 2 feet below the surface of the ground; also marked by a cross in the vertical line through center of copper bolt cut in a rock placed flush with the surface of the ground, from which the northeast corner of an implement house bears (counting from the south point to west) 61° 54′; distance, 151.9 feet.

[Latitude, 33° 33′ 46.27″. Longitude, 96° 41′ 50.98″.]

To station—	Azimuth.	Back azimuth.	Log. distance.
	° ′ ″	° ′ ″	*Meters.*
County line	125 08 20.82	304 59 30.94	4.4787932
Dexter	140 31 41.84	320 23 13.12	4.5693849
Good	196 18 59.97	16 20 39.89	4.2183856

SPIRIT LEVELING.

The elevations in the following list are based on bench mark XLI of the United States Coast and Geodetic Survey, located at Fort Smith, Arkansas. This mark was placed in 1889, and is a copper bolt leaded in the west wall of the United States jail (brick). The bolt is in the first course above the limestone base, and about 1 meter above the ground. It is in the fifth brick from the panel formed by the side of the building and the brick ventilator. The jail is a new pressed-brick addition to the old United States building. A cross was cut in the end of the bolt, and the intersection of the lines forming the cross is the bench mark. The letters "U. S. B. M." were cut in the base stone immediately below the bolt. Height above the mean level of the Gulf, 446.29 feet.

From this bench mark two lines of levels were run, one over the St. Louis, Iron Mountain and Southern Railway to Wagoner, Indian Territory; then south over the Missouri, Kansas and Texas Railway to milepost No. 519, where a closure of 0.430 feet was made on the other line of levels which had been run from Fort Smith, Arkansas, over the St. Louis and San Francisco Railroad to Wister, Indian Territory; then west over the Choctaw, Oklahoma and Gulf Railroad to South McAlester, Indian Territory; then north over the Missouri, Kansas and Texas Railway to mile pole No. 519. The level lines from Fort Smith, Arkansas, to Wagoner, Indian Territory, and Fort Smith, Arkansas, to South McAlester, Indian Territory, were run by two levelmen over each line. Messrs. J. Phelan and C. H. Hickman started the line from Fort Smith, Arkansas, to Wagoner, Indian Territory, but were afterwards relieved by Messrs. A. F. Hassan and R. Coe. Messrs. R. Coe and G. A. Purington started the line from Fort Smith, Arkansas, to South McAlester, Indian Territory, but Mr. Coe was afterwards relieved by Mr. H. C. McCluer. The remainder of the railroad levels were run by a single levelman using two rods. From Wister, Indian Territory, Mr. H. C. McCluer ran south over the St. Louis and San Francisco Railroad to Paris, Texas; and then west over the Texas and Pacific Railway to Sherman, Texas, where a closure of 0.915 feet was made with line run by Messrs. G. A. Purington and W. R. Manning south over the Missouri, Kansas and Texas Railway to Sherman, Texas. Starting from Denison, Texas, on the Missouri, Kansas and Texas Railway, Messrs. R. Coe and R. T. Carnall ran west over said line to Gainesville, Texas. From that point the line was carried north by Messrs. R. Coe and A. F. Hassan over the Gulf, Colorado and Santa Fe Railway to Oklahoma City, Oklahoma Territory; then east by Mr. R. Coe over the Choctaw, Oklahoma and Gulf Railroad to mile pole No. 66, near Dale, Oklahoma Territory,

where a closure of 0.146 feet was made with line brought west by Mr. E. L. Faison from South McAlester, Indian Territory, over the Choctaw, Oklahoma and Gulf Railroad. From Oklahoma City, Oklahoma Territory, Mr. R. Coe ran west over the Choctaw, Oklahoma and Gulf Railroad to Fort Reno, Oklahoma Territory, and then south from El Reno Junction, Oklahoma Territory, over the Chicago, Rock Island and Pacific Railway through Indian Territory to the Red River. Then returning a few miles north to the intersection of the railway with the first standard parallel south, of the Chickasaw Survey, he ran east along the said parallel to the Indian meridian, where he made a closure of 0.566 feet on the line of levels extended by Mr. J. H. Carlock westward from the Gulf, Colorado and Santa Fe Railway to the Indian meridian. Elevations of the portions of this circuit that lay in Oklahoma Territory have been included by Mr. J. H. Renshawe, topographer, in the report for the fiscal year 1897–98.

From Wagoner, Indian Territory, levels were run north by Messrs. A. F. Hassan, C. B. Odell, and R. Coe, over the Missouri, Kansas and Texas Railway to Chetopah, Kansas, and from there west by Mr. R. Coe, over the Missouri Pacific Railway to Coffeyville, Kansas, making a closure of 1.009 feet on line run north from Wagoner, Indian Territory, by Mr. C. B. Odell over the St. Louis, Iron Mountain and Southern Railway to Coffeyville, Kansas. Levels were also run on the St. Louis and San Francisco Railroad from Sapulpa, Indian Territory, to its intersection with the Indian Territory-Missouri line, crossing the St. Louis, Iron Mountain and Southern Railway at Claremore, Indian Territory, and the Missouri, Kansas and Texas Railway at Vinita, Indian Territory; along the Kansas City, Pittsburg and Gulf Railroad, from the Indian Territory-Arkansas line, near Page, Indian Territory, north to Siloam Springs, Arkansas, crossing the St. Louis and San Francisco Railroad near Poteau, Indian Territory, and St. Louis, Iron Mountain and Southern Railway near Sallisaw, Indian Territory.

It will be seen from the above résumé that Indian Territory has been well controlled by double-rodded lines along the various railroads, all so run as to form closed circuits, which have all closed quite satisfactorily considering the conditions of extreme heat and cold, as well as high winds, which existed at various times during the work. These lines along the railroads were used as precise levels, and all land lines were connected to these at the points of intersection.

All permanent bench marks were stamped to the nearest foot.

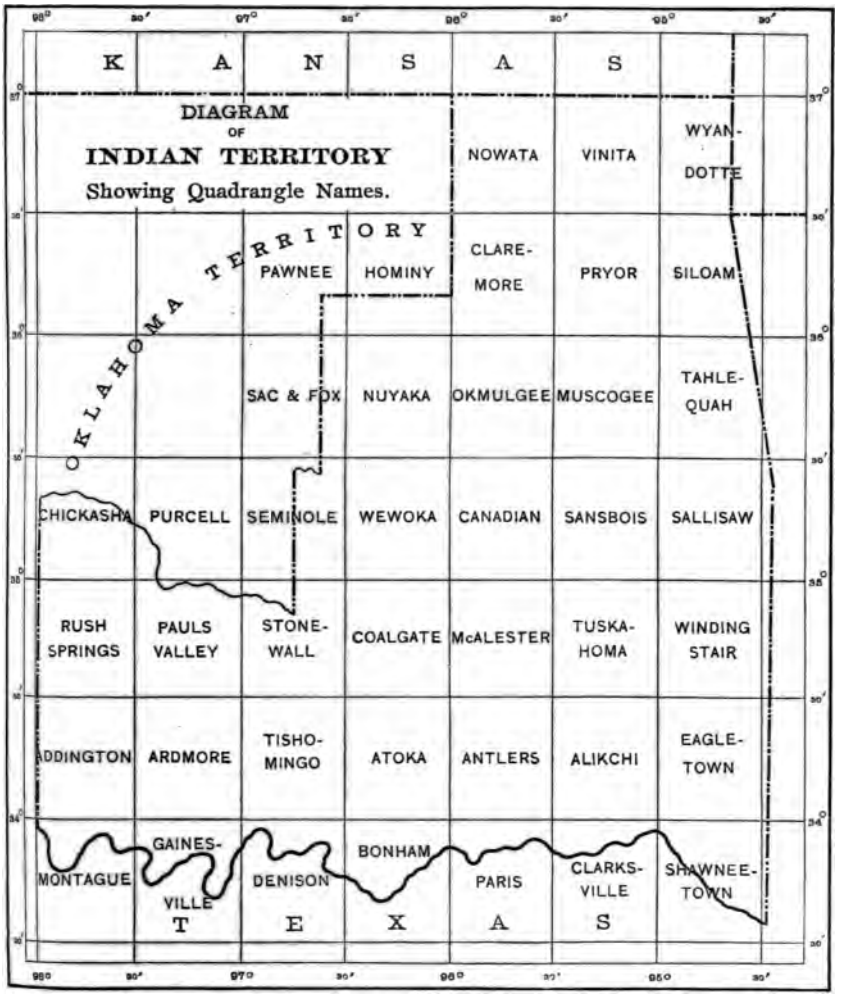

FIG. 1.—Map of Indian Territory showing quadrangle names.

WYANDOTTE QUADRANGLE.

Mr. A. F. Hassan ran the railroad levels. Mr. George Nick was attached to the subdivision and topographic party of Mr. D. C. Harrison, and Messrs. W. E. Earle and H. L. Muldrow, jr., to Mr. R. H. McKee's party.

FROM AFTON, ALONG THE ST. LOUIS AND SAN FRANCISCO RAILROAD, TO MISSOURI-SHAWNEE BOUNDARY LINE.

	Feet.
Afton, ⅓ mile north of; copper bolt sunk into coping stone on south side of west abutment of bridge 245, over Horse Creek	773.867
Fairland, 1 mile south of; spike in mile pole 343	819.048

	Feet.
Fairland, 5 miles north of; spike in mile pole 337	734.505
Wyandotte, 2 miles south of; copper bolt sunk into south coping stone of west abutment of bridge over Grand River	743.078
Wyandotte, 5 miles north of; copper bolt sunk into stone on south side of west pier, bridge 222, over Lees Creek	814.347
Missouri-Shawnee boundary line; iron post set 10 feet north of track and 4 feet south of "State Line" signboard	846.411

ALONG TOWNSHIP AND SECTION LINES.

Closing corner T. 28 N., Rs. 21 and 22 E., iron post	772.234
Grand River meander corner between sec. 6, T. 28 N., R. 22 E., and sec. 35, T. 29 N., R. 21 E.; iron post on right bank of	773.010
Grand River meander corner between sec. 6, T. 27 N., R. 23 E., and sec. 31, T. 28 N., R. 23 E.; iron post on right bank of	740.090
Corner Ts. 27 and 28 N., Rs. 22 and 23 E., iron post	771.642
Corner Ts. 27 and 28 N., Rs. 21 and 22 E., iron post	807.345
Corner Ts. 26 and 27 N., Rs. 21 and 22 E., iron post	762.992
Corner Ts. 26 and 27 N., Rs. 22 and 23 E., iron post	793.672
Grand River meander corner between sec. 36, T. 27 N., and sec. 1, T. 26 N., R. 23 E.; iron post on right bank of	726.994
Grand River meander corner between sec. 32, T. 26 N., and sec. 5, T. 25 N., R. 24 E.; iron post on right bank of	701.431
Corner Ts. 25 and 26 N., Rs. 23 and 24 E., iron post	735.451
Corner Ts. 25 and 26 N., Rs. 22 and 23 E., iron post	849.611
Corner Ts. 25 and 26 N., Rs. 21 and 22 E., iron post	778.761
Standard corner T. 25 N., Rs. 21 and 22 E., iron post	834.693
Closing corner T. 24 N., Rs. 22 and 23 E., iron post	698.113
Standard corner T. 25 N., Rs. 22 and 23 E., iron post	734.553
Closing corner T. 24 N., Rs. 23 and 24 E., iron post	754.643
Standard corner T. 25 N., Rs. 23 and 24 E., iron post	751.273
Closing corner T. 24 N., Rs. 24 and 25 E., iron post	877.443
Standard corner T. 25 N., Rs. 24 and 25 E., iron post	875.973
Missouri-Cherokee boundary line, closing corner Ts. 24 and 25 N., R. 25 E., iron post	903.793
Seneca-Cherokee boundary line, closing corner T. 25 N., Rs. 23 and 24 E., iron post	772.163
Seneca-Cherokee boundary line, closing corner T. 25 N., Rs. 24 and 25 E., iron post	832.883
Seneca-Cherokee boundary line, intersection of the, with the west boundary line of Missouri, T. 25 N., R. 25 E., of Indian Territory Survey, iron post.	751.113
Arkansas-Cherokee boundary line, closing corner Ts. 23 and 24 N., R. 25 E., iron post	1,030.273
Corner Ts. 23 and 24 N., Rs. 24 and 25 E., iron post	1,029.483
Corner Ts. 23 and 24 N., Rs. 23 and 24 E., iron post	900.453
Corner Ts. 23 and 24 N., Rs. 22 and 23 E., iron post	893.849

VINITA QUADRANGLE.

The railroad levels were run by Messrs. R. Coe, C. B. Odell, and A. F. Hassan. Mr. C. B. Odell had charge of an independent level party. Mr. G. Nick was attached to the subdivision and topographic party of Mr. D. C. Harrison, and Messrs. E. W. Hill, W. E. Earle, and *A. F. Hassan* were with Mr. R. H. McKee's party.

IG CABIN, ALONG THE MISSOURI, KANSAS AND TEXAS AILWAY, TO KANSAS–CHEROKEE BOUNDARY LINE.

	Feet.
n, 2 miles north of; spike in telegraph mile pole 445	690.998
n, 3¾ miles north of; copper bolt set into angle coping stone of le of north abutment of bridge 227 over Whiteoak Creek near ole 443	667.232
ron post in northwest angle of Missouri, Kansas and Texas and ıis and San Francisco railroads; 13.8 feet west of the Missouri, ı and Texas track and 22.9 feet north of the St. Louis and San ıco track, 4.2 feet north of a telegraph pole	695.216
ɔronze tablet set into second stone from north end of second of foundation stone above sidewalk of Hotel Cobb, which is a ıuilding owned by S. S. Cobb	702.469
mile north of; copper bolt sunk into bottom stone of east side of ıbutment of bridge 220, 160 feet north of mile pole 433	748.998
ɛt; square hole cut in sandstone post, 4 by 13 inches, surface flush ound, situated between main track and "house track," south of building; 22.9 feet from west rail of main track, 21.5 feet from l of house track, and 42.4 feet from south end of building	773.565
ɛt, 2 miles north of; ¼ mile north of mile pole 425; copper bolt ıto seat stone, 8 inches from west edge of, on west side of south ɛnt of bridge 217	761.622
miles north of; spike in first telegraph pole south of mile pole	852.864
reek, 2 miles north of; copper bolt sunk into first step on east north abutment of bridge 213, 1,400 feet north of mile pole 414	798.416
herokee boundary line, intersection of railroad with; square hole stone post 14 by 14 by 5 inches, flush with ground, 49.6 feet from il of track and referenced by three posts situated as follows: 3.4 rthwest, 2.5 feet east, and 4 feet southwest from stone	835.495

HELSEA, ALONG THE ST. LOUIS AND SAN FRANCISCO RAILROAD, TO ALBIA.

copper bolt in sandstone post 8 by 10 by 22 inches, buried flush round, 11.5 feet from northwest corner of station building and ɛt from east rail of track	715.147
bronze tablet set into northeast corner of stone building, corner e and Fifth streets, used as a bank building	717.951
6 miles northeast of; spike in milepole 375	798.641
miles southwest of; spike in milepole 369	760.078
mile west of; copper bolt sunk into southwest coping stone of ıbutment of bridge over Big Cabin Creek	676.091
miles southwest of; spike in milepole 356	694.676

ALONG TOWNSHIP LINES.

herokee boundary line, closing corner T. 29 N., Rs. 17 and 18 E., st	900.945
herokee boundary line, closing corner T. 29 N., Rs. 18 and 19 E., st	934.823
herokee boundary line, closing corner T. 29 N., Rs. 19 and 20 E., st	905.385

	Feet.
Kansas-Cherokee boundary line, closing corner T. 29 N., Rs. 20 and 21 E., iron post	827.024
Kansas-Cherokee boundary line, iron post set by the side of the "Zero" milepost and 400 feet west of the Neosho or Grand River	780.029
Standard corner T. 29 N., Rs. 20 and 21 E., iron post	833.01
Closing corner T. 28 N., Rs. 20 and 21 E., iron post	887.803
Standard corner T. 29 N., Rs. 19 and 20 E., iron post	945.791
Closing corner T. 28 N., Rs. 19 and 20 E., iron post	894.993
Standard corner T. 29 N., Rs. 18 and 19 E., iron post	956.136
Closing corner T. 28 N., Rs. 18 and 19 E., iron post	894.876
Standard corner T. 29 N., Rs. 17 and 18 E., iron post	827.136
Closing corner T. 28 N., Rs. 17 and 18 E., iron post	845.136
Corner Ts. 27 and 28 N., Rs. 17 and 18 E., iron post	803.09
Corner Ts. 27 and 28 N., Rs. 18 and 19 E., iron post	823.87 6
Corner Ts. 27 and 28 N., Rs. 19 and 20 E., iron post	956.0
Corner Ts. 27 and 28 N., Rs. 20 and 21 E., iron post	791.0
Corner Ts. 26 and 27 N., Rs. 20 and 21 E., iron post	772.0
Corner Ts. 26 and 27 N., Rs. 19 and 20 E., iron post	755.9 1
Corner Ts. 26 and 27 N., Rs. 18 and 19 E., iron post	827.2 2
Corner Ts. 26 and 27 N., Rs. 17 and 18 E., iron post	777.0
Corner Ts. 25 and 26 N., Rs. 17 and 18 E., iron post	733.3
Corner Ts. 25 and 26 N., Rs. 18 and 19 E., iron post	794.3 7
Corner Ts. 25 and 26 N., Rs. 19 and 20 E., iron post	718.2 1
Corner Ts. 25 and 26 N., Rs. 20 and 21 E., iron post	739.3 21
Closing corner T. 24 N., Rs. 21 and 22 E., iron post	821.0 33
Standard corner T. 25 N., Rs. 20 and 21 E., iron post	673.0 56
Closing corner T. 24 N., Rs. 20 and 21 E., iron post	716.1 13
Standard corner T. 25 N., Rs. 19 and 20 E., iron post	686.4 26
Closing corner T. 24 N., Rs. 19 and 20 E., iron post	696.7 67
Standard corner T. 25 N., Rs. 18 and 19 E., iron post	909.0
Closing corner T. 24 N., Rs. 18 and 19 E., iron post	895.8 88
Standard corner T. 25 N., Rs. 17 and 18 E., iron post	785.8 96
Corner Ts. 23 and 24 N., Rs. 17 and 18 E., iron post	709.7 01
Corner Ts. 23 and 24 N., Rs. 18 and 19 E., iron post	840.1 27
Corner Ts. 23 and 24 N., Rs. 19 and 20 E., iron post	682.2 69
Witness corner to Ts. 23 and 24 N., Rs. 20 and 21 E., iron post	656.6 63
Corner Ts. 23 and 24 N., Rs. 21 and 22 E., iron post. (This bench mark is just north of the Vinita quadrangle and on the Missouri, Kansas and Texas Railway.)	820.0 59
Chetopah, Kansas; bronze tablet set in center of corner stone on east side of entrance and in first course of stone above foundation of public-school building	823.7 01

NOWATA QUADRANGLE.

Mr. C. B. Odell ran the railroad levels; Mr. W. S. D. Moore had an independent level party; Messrs. G. Nick and J. P. Thayer were attached to the subdivision and topographic party of Mr. D. C. Harrison, and Mr. A. F. Hassan was with Mr. R. H. McKee's party.

TALALA, ALONG ST. LOUIS, IRON MOUNTAIN AND SOUTHERN RAILWAY, TO SEMINOLE.

	Feet.
copper bolt in sandstone post 7 by 9 by 18 inches, buried flush ground, 8.6 feet from southeast corner of station building	683.305
, 2 miles south of; telegraph milepole 639	693.476
, 2 miles south of; spike in second telegraph pole north of mile-345	703.138
; copper bolt in sandstone post 8 by 8 by 26 inches, buried flush ground, 8.7 feet south from southeast corner of station building 4 feet from track	693.5
; bronze tablet set into sandstone sill, northeast corner of J. H. ett's "City Dry Goods Store"	702.419
, 3 miles north of; square hole cut into second capstone from east f center pier bridge over California Creek	660.791
h, 3 miles north of; spike in milepole 654	750.384
le, 3 miles south of; spike in milepole 660	707.496
le, 3 miles south of; spike in milepole 666	716.356
le, 4 miles north of; copper bolt sunk into sandstone post 6 by 8 inches, buried flush with ground, 8.8 feet west of track and 1.4 rom post marking intersection of railroad and Kansas-Cherokee dary line, which is near thirty-fourth milepost of boundary line	730.504

ALONG TOWNSHIP AND SECTION LINES.

-Cherokee boundary line, closing corner Osage-Cherokee boundary T. 29 N., R. 12 E., iron post	941.681
-Cherokee boundary line, closing corner T. 29 N., Rs. 12 and 13 E., post	719.136
-Cherokee boundary line, closing corner T. 29 N., Rs. 13 and 14 E., post	806.136
-Cherokee boundary line, closing corner T. 29 N., Rs. 14 and 15 E., post	872.951
-Cherokee boundary line, closing corner T. 29 N., Rs. 15 and 16 E., post	735.205
-Cherokee boundary line, closing corner T. 29 N., Rs. 16 and 17 E., post	757.205
rd corner T. 29 N., Rs. 16 and 17 E., iron post	808.136
; corner T. 28 N., Rs. 16 and 17 E., iron post	737.136
rd corner T. 29 N. Rs. 15 and 16 E., iron post	713.354
; corner T. 28 N., Rs. 15 and 16 E., iron post	758.337
rd corner T. 29 N., Rs. 14 and 15 E., iron post	946.136
; corner T. 28 N., Rs. 14 and 15 E., iron post	919.919
rd corner T. 29 N., Rs. 13 and 14 E., iron post	781.136
; corner T. 28 N., Rs. 13 and 14 E., iron post	740.226
rd corner T. 29 N., Rs. 12 and 13 E., iron post	704.136
; corner T. 28 N., Rs. 12 and 13 E., iron post	741.419
Cherokee boundary line, closing corner Ts. 28 and 29 N., R. 12 E., post	793.136
Cherokee boundary line, closing corner Ts. 27 and 28 N., R. 12 E., post	692,269
Ts. 27 and 28 N., Rs. 12 and 13 E., iron post	688.011
Ts. 27 and 28 N., Rs. 13 and 14 E., iron post	799.349

	Feet.
Corner Ts. 27 and 28 N., Rs. 14 and 15 E., iron post	845.989
Triangulation station; northeast part of NW. ¼ sec. 5, T. 28 N., R. 15 E., copper bolt in stone, 20 feet left of signal tower	968.497
Corner Ts. 27 and 28 N., Rs. 15 and 16 E., iron post	795.869
Corner Ts. 27 and 28 N., Rs. 16 and 17 E., iron post	707.841
Corner Ts. 26 and 27 N., Rs. 16 and 17 E., iron post	738.937
Corner Ts. 26 and 27 N., Rs. 15 and 16 E., iron post	688.804
Corner Ts. 26 and 27 N., Rs. 14 and 15 E., iron post	895.509
Corner Ts. 26 and 27 N., Rs. 13 and 14 E., iron post	813.747
Corner Ts. 26 and 27 N., Rs. 12 and 13 E., iron post	667.491
Osage-Cherokee boundary line, closing corner Ts. 26 and 27 N., R. 12 E., iron post	672.977
Osage-Cherokee boundary line, closing corner Ts. 25 and 26 N., R. 12 E., iron post	922.966
Corner Ts. 25 and 26 N., Rs. 12 and 13 E., iron post	654.498
Corner Ts. 25 and 26 N., Rs. 13 and 14 E., iron post	717.625
Corner Ts. 25 and 26 N., Rs. 14 and 15 E., iron post	761.842
Triangulation signal; south central part of SW. ¼ sec. 33, T. 26 N., R. 15 E., copper bolt set in stone 6 inches square	903.057
Corner Ts. 25 and 26 N., Rs. 15 and 16 E., iron post	690.122
Corner Ts. 25 and 26 N., Rs. 16 and 17 E., iron post	641.31
Standard corner T. 25 N., Rs. 16 and 17 E., iron post	648.0
Closing corner T. 24 N., Rs. 16 and 17 E., iron post	636.232
Standard corner T. 25 N., Rs. 15 and 16 E., iron post	695.105
Closing corner T. 24 N., Rs. 15 and 16 E., iron post	685.16
Standard corner T. 25 N., Rs. 14 and 15 E., iron post	811.02
Closing corner T. 24 N., Rs. 14 and 15 E., iron post	807.88
Standard corner T. 25 N., Rs. 13 and 14 E., iron post	626.605
Closing corner T. 24 N., Rs. 13 and 14 E., iron post	627.995
Standard corner T. 25 N., Rs. 12 and 13 E., iron post	733.698
Closing corner T. 24 N., Rs. 12 and 13 E., iron post	731.888
Osage-Cherokee boundary line, closing corner Ts. 24 and 25 N., R. 12 E., iron post	840.708
Osage-Cherokee boundary line, closing corner Ts. 23 and 24 N., R. 12 E., iron post	879.665
Corner Ts. 23 and 24 N., Rs. 12 and 13 E., iron post	790.033
Corner Ts. 23 and 24 N., Rs. 13 and 14 E., iron post	613.463
Corner Ts. 23 and 24 N., Rs. 14 and 15 E., iron post	694.357
Corner Ts. 23 and 24 N., Rs. 15 and 16 E., iron post	763.796
Corner Ts. 23 and 24 N., Rs. 16 and 17 E., iron post	749.749

The following bench marks are situated just north of the Nowata quadrangle, and are on the Missouri Pacific and St. Louis, Iron Mountain and Southern Railways:

	Feet.
Edna, Labette County, Kansas; bronze tablet in middle of bottom stone of north column of stone store building, owned by G. W. Reason, and used as a grocery by Arnold Bros	974.0497
Coffeyville, Kansas; copper bolt in sandstone post, 6 by 8 by 24 inches flush with ground near Missouri Pacific station building, and 1.8 feet south of station, 20.1 feet north of north rail	743.778
Coffeyville, Kansas; bronze tablet on base of pilaster of red sandstone in the Ried Building, on the southeast corner of Walnut and Ninth streets, *and in northwest* corner of building	731.372

CLAREMORE QUADRANGLE.

Mr. C. B. Odell ran the railroad levels. Messrs. W. S. D. Moore and C. B. Odell had independent level parties. Mr. A. F. Hassan was attached to the subdivision and topographic party of Mr. R. H. McKee, and Mr. J. P. Thayer to Mr. D. C. Harrison's party.

FROM INOLA, ALONG THE ST. LOUIS, IRON MOUNTAIN AND SOUTHERN RAILWAY, TO OOLOGAH.

	Feet.
Inola; copper bolt sunk into sandstone post, 4 by 6 by 24 inches, buried flush with surface and 10.2 feet from the southeast corner of station building	599.821
Inola, 6 miles north of; spike in mile pole 609	601.201
Claremore; bronze tablet set into top course of foundation stone of First National Bank Building, on the southwest corner of same. Building situated on the northeast corner of Third street and Wichita avenue	599.077
Claremore; copper bolt sunk into sandstone post 8 by 8 by 18 inches, 9.1 feet south from southeast corner of station building, 12.6 feet west of St. Louis, Iron Mountain and Southern track	607.01
Claremore, 1 mile north of; copper bolt sunk into sandstone post 6 by 9 by 20 inches, flush with surface, 7.8 feet east of St. Louis, Iron Mountain and Southern Railway, and 7.8 feet west of St. Louis and San Francisco Railroad tracks, 27.6 feet north of the intersection of these roads	611.164
Sageeyah; (+) cross on sandstone post 9 by 9 by 18 inches, 10 feet west of track and 12 feet south from southeast corner of station building	643.515
Sageeyah, 1 mile north of; "U. S. B. M." stamped in southeast iron tube near center of bridge structure over Verdigris River	592.489
Oologah; copper bolt sunk into stone 7 by 9 by 17 inches, 10.7 feet from south end of station and 12 feet from track, and buried flush with surface	654.614

FROM CLAREMORE, ALONG THE ST. LOUIS AND SAN FRANCISCO RAILROAD, TO TULSA.

Claremore, 6 miles north of; spike in mile pole 392	687.785
Claremore; St. Louis and San Francisco Railroad station; copper bolt sunk into sandstone post 8 by 8 by 20 inches, 10.4 feet from northwest corner of building, 18.7 feet east of track and buried flush with surface	598.687
Verdigris; spike in mile pole 404	619.376
Catoosa, 1 mile north of; copper bolt sunk into capstone on south side of east pier, bridge over Verdigris River	570.724
Catoosa; spike in mile pole 410, opposite station building	617.144
Catoosa, 3 miles south of; spike in mile pole 413	738.043
Tulsa, 6 miles north of; square hole cut in first capstone on south end of east abutment, bridge over Mingo Creek	601.568
Tulsa; copper bolt sunk into sandstone post 8 by 8 by 22 inches, 18.6 feet west of track and 12.7 feet from southeast corner of station building and buried flush with surface	695.127
Tulsa; bronze tablet set into southwest corner stone of second course above sidewalk of stone building known as the Lynch Building	708.038
Tulsa, ½ mile south of; copper bolt sunk into west side of north pier, bridge over Arkansas River	640.95

ALONG TOWNSHIP LINES.

	Feet.
Corner Ts. 22 and 23 N., Rs. 16 and 17 E., iron post	736.19
Corner Ts. 22 and 23 N., Rs. 15 and 16 E., iron post	617.23
Corner Ts. 22 and 23 N., Rs. 14 and 15 E., iron post	663.665
Corner Ts. 22 and 23 N., Rs. 13 and 14 E., iron post	626.285
Corner Ts. 22 and 23 N., Rs. 12 and 13 E., iron post	662.745
Oklahoma-Cherokee boundary line, closing corner Ts. 22 and 23 N., R. 12 E., iron post	644.305
Corner Ts. 21 and 22 N., Rs. 16 and 17 E., iron post	659.045
Corner Ts. 21 and 22 N., Rs. 15 and 16 E., iron post	622.6
Corner Ts. 21 and 22 N., Rs. 14 and 15 E., iron post	717.3
Corner Ts. 21 and 22 N., Rs. 13 and 14 E., iron post	687.345
Corner Ts. 21 and 22 N., Rs. 12 and 13 E., iron post	627.51
Oklahoma-Cherokee boundary line, closing corner Ts. 21 and 22 N., R. 12 E., iron post	618.175
Oklahoma-Cherokee boundary line, closing corner Ts. 20 and 21 N., R. 12 E., iron post	746.34
Closing corner T. 20 N., Rs. 12 and 13 E., iron post	627.185
Standard corner T. 21 N., Rs. 12 and 13 E., iron post	624.61
Closing corner T. 20 N., Rs. 13 and 14 E., iron post	579.08
Standard corner T. 21 N., Rs. 13 and 14 E., iron post	577.995
Closing corner T. 20 N., Rs. 14 and 15 E., iron post	785.005
Standard corner T. 21 N., Rs. 14 and 15 E., iron post	794.135
Closing corner T. 20 N., Rs. 15 and 16 E., iron post	594.316
Standard corner T. 21 N., Rs. 15 and 16 E., iron post	596.516
Closing corner T. 20 N., Rs. 16 and 17 E., iron post	603.427
Standard corner T. 21 N., Rs. 16 and 17 E., iron post	612.905
Corner Ts. 19 and 20 N., Rs. 16 and 17 E., iron post	618.161
Corner Ts. 19 and 20 N., Rs. 15 and 16 E., iron post	644.111
Corner Ts. 19 and 20 N., Rs. 14 and 15 E., iron post	629.821
Corner Ts. 19 and 20 N., Rs. 13 and 14 E., iron post	614.821
Witness corner Ts. 19 and 20 N., Rs. 12 and 13 E., iron post	714.821
Corner Ts. 18 and 19 N., Rs. 12 and 13 E., iron post	627.679
Corner Ts. 18 and 19 N., Rs. 13 and 14 E., iron post	693.349
Corner Ts. 18 and 19 N., Rs. 14 and 15 E., iron post	698.139
Corner Ts. 18 and 19 N., Rs. 15 and 16 E., iron post	749.849
Corner Ts. 18 and 19 N., Rs. 16 and 17 E., iron post	539.579

PRYOR QUADRANGLE.

The railroad levels were run by Messrs. C. B. Odell, A. F. Hassan, and R. Coe. Mr. W. S. D. Moore had charge of an independent level party. Messrs. A. F. Hassan, E. W. Hill, J. P. Phelan, W. E. Earle, and H. L. Muldrow, jr., were attached to the subdivision and topographic party of Mr. R. H. McKee.

ON ST. LOUIS AND SAN FRANCISCO RAILROAD.

	Feet.
Chelsea, 4 miles south of; spike in mile pole 385	749.466

FROM LELIAETTA, ALONG THE MISSOURI, KANSAS AND TEXAS RAILWAY, TO BIG CABIN.

Leliaetta, 2 miles north of; square hole cut in a limestone post, the exposed surface of which is 1.1 feet by 0.45 feet, buried flush with ground between sixth and seventh telegraph poles north of mile pole 482, 50 feet from *north telegraph* pole, and 27 feet left of track	580.084

	Feet.
Mazie; spike in telegraph mile pole 478	608.725
Choteau; square hole cut in sandstone post 6 by 10 by 18 inches, buried flush with ground 10 feet west of track and 10.5 feet south of station building	625.235
Choteau, 1 mile north of; square hole cut into coping stone west side of south pier, bridge over Choteau Creek	585.294
Pryor Creek, 2 miles south of; square hole cut into coping stone, northwest corner of north abutment bridge 244, over Pryor Creek	595.632
Pryor Creek; $\frac{\text{U. S.}}{\text{B. M.}}$ + cut in sandstone post 2 by 4 by 24 inches, which is buried flush with ground near southeast corner of station building	625.236
Pryor Creek; bronze tablet set into third course of stone above sidewalk of south end of general merchandise store occupied by J. L. Baugh	630.976
Perry, 2 miles south of; square hole cut into second coping stone of east end of the south abutment bridge 237, near mile pole 460	614.849
Perry, 1 mile north of; copper bolt sunk into east coping stone of south abutment bridge 235, 2,000 feet north of mile pole 457	649.499
Adair, 3 miles north of; copper bolt sunk into top stone of ballast wall on east side of south abutment bridge over Rock Creek, about one-fourth mile north of mile pole 451	661.277
Big Cabin, 3 miles south of; square hole cut into top stone at east end of south abutment bridge 230, near mile pole 450	659.925

ALONG TOWNSHIP LINES.

Corner Ts. 22 and 23 N., Rs. 17 and 18 E., iron post	803.656
Corner Ts. 22 and 23 N., Rs. 18 and 19 E., iron post	633.496
Corner Ts. 22 and 23 N., Rs. 19 and 20 E., iron post	657.896
Corner Ts. 22 and 23 N., Rs. 20 and 21 E., iron post	689.656
Corner Ts. 22 and 23 N., Rs. 21 and 22 E., iron post	854.443
Corner Ts. 21 and 22 N., Rs. 21 and 22 E., iron post	1,013.253
Corner Ts. 21 and 22 N., Rs. 20 and 21 E., iron post	942.151
Corner Ts. 21 and 22 N., Rs. 19 and 20 E., iron post	670.751
Witness corner Ts. 21 and 22 N., Rs. 18 and 19 E., iron post	606.36
Corner Ts. 21 and 22 N., Rs. 17 and 18 E., iron post	797.892
Closing corner T. 20 N., Rs. 17 and 18 E., iron post	626.954
Standard corner T. 21 N., Rs. 17 and 18 E., iron post	628.744
Closing corner T. 20 N., Rs. 18 and 19 E., iron post	618.974
Standard corner T. 21 N., Rs. 18 and 19 E., iron post	620.204
Closing corner T. 20 N., Rs. 19 and 20 E., iron post	655.533
Standard corner T. 21 N., Rs. 19 and 20 E., iron post	660.595
Closing corner T. 20 N., Rs. 20 and 21 E., iron post	891.033
Witness corner to standard corner T. 21 N., Rs. 20 and 21 E., iron post	785.613
Closing corner T. 20 N., Rs. 21 and 22 E., iron post	960.913
Standard corner T. 21 N., Rs. 21 and 22 E., iron post	998.423
Corner Ts. 19 and 20 N., Rs. 21 and 22 E., iron post	1,124.823
Corner Ts. 19 and 20 N., Rs. 20 and 21 E., iron post	900.015
Corner Ts. 19 and 20 N., Rs. 19 and 20 E., iron post	642.685
Corner Ts. 19 and 20 N., Rs. 18 and 19 E., iron post	653.165
Corner Ts. 19 and 20 N., Rs. 17 and 18 E., iron post	626.855
Corner Ts. 18 and 19 N., Rs. 17 and 18 E., iron post	608.054
Corner Ts. 18 and 19 N., Rs. 18 and 19 E., iron post	626.16

	Feet.
Corner Ts. 18 and 19 N., Rs. 19 and 20 E., iron post	883.755
Corner Ts. 18 and 19 N., Rs. 20 and 21 E., iron post	918.786
Corner Ts. 18 and 19 N., Rs. 21 and 22 E., iron post	963.046

SILOAM QUADRANGLE (INDIAN TERRITORY—ARKANSAS).

The railroad levels were run by Messrs. R. Coe and W. S. D. Moore. Messrs. W. E. Earle, G. Nick, E. W. Hill, S. C. Pitts, and H. L. Muldrow, jr., were attached to the subdivision and topographic party of Mr. R. H. McKee.

ALONG THE KANSAS CITY, PITTSBURG AND GULF RAILROAD TO SILOAM SPRINGS, ARKANSAS.

	Feet.
Corner Ts. 18 and 19 N., Rs. 25 and 26 E., iron post 12 chains west from railroad	1,042.878
Intersection of railroad with Arkansas-Cherokee boundary line, iron post.	970.83
Siloam Springs; iron post at southwest corner of platform, 60 feet south of station building and 15 feet west of track	1,148.604

ALONG TOWNSHIP LINES.

Corner Ts. 22 and 23 N., Rs. 22 and 23 E., iron post	1,022.786
Corner Ts. 22 and 23 N., Rs. 23 and 24 E., iron post	1,058.716
Corner Ts. 22 and 23 N., Rs. 24 and 25 E., iron post	1,130.953
Arkansas-Cherokee boundary line, closing corner Ts. 22 and 23 N., R. 25 E., iron post	1,064.453
Arkansas-Cherokee boundary line; witness to closing corner Ts. 21 and 22 N., R. 25 E., iron post	982.812
Corner Ts. 21 and 22 N., Rs. 24 and 25 E., iron post	976.663
Corner Ts. 21 and 22 N., Rs. 23 and 24 E., iron post	1,029.203
Corner Ts. 21 and 22 N., Rs. 22 and 23 E., iron post	964.553
Closing corner T. 20 N., Rs. 22 and 23 E., iron post	1,056.473
Standard corner T. 21 N., Rs. 22 and 23 E., iron post	998.103
Closing corner T. 20 N., Rs. 23 and 24 E., iron post	1,095.003
Standard corner T. 21 N., Rs. 23 and 24 E., iron post	1,086.423
Closing corner T. 20 N., Rs. 24 and 25 E., iron post	1,139.403
Standard corner T. 21 N., Rs. 24 and 25 E., iron post	1,158.543
Closing corner T. 20 N., Rs. 25 and 26 E., iron post	1,158.085
Arkansas-Cherokee boundary line, closing corner Ts. 20 and 21 N., R. 25 E., iron post	1,137.313
Arkansas-Cherokee boundary line, closing corner Ts. 19 and 20 N., R. 26 E., iron post	1,147.027
Corner Ts. 19 and 20 N., Rs. 25 and 26 E., iron post	1,124.022
Corner Ts. 19 and 20 N., Rs. 24 and 25 E., iron post	973.993
Corner Ts. 19 and 20 N., Rs. 23 and 24 E., iron post	1,108.623
Corner Ts. 19 and 20 N., Rs. 22 and 23 E., iron post	1,105.753
Corner Ts. 18 and 19 N., Rs. 22 and 23 E., iron post	1,002.273
Corner Ts. 18 and 19 N., Rs. 23 and 24 E., iron post	1,045.231
Corner Ts. 18 and 19 N., Rs. 24 and 25 E., iron post	1,074.378
Arkansas-Cherokee boundary line, closing corner Ts. 18 and 19 N., R. 26 E., iron post	1,095.662

WINSLOW QUADRANGLE (INDIAN TERRITORY-ARKANSAS).

Levels for this small fractional quadrangle were run by Mr. J. H. Carlock, of Mr. C. W. Goodlove's party, and Mr. H. M. Tidwell, of Mr. R. H. McKee's party.

ALONG TOWNSHIP LINES.

	Feet.
Arkansas-Choctaw boundary line, closing corner Ts. 15 and 16 N., R. 26 E., iron post	1,062.238
Corner of Ts. 14 and 15 N., Rs. 26 and 27 E., iron post	1,574.13
Arkansas-Choctaw boundary line, closing corner Ts. 14 and 15 N., R. 27 E., iron post	1,581.43
Arkansas-Choctaw boundary line, closing corner Ts. 13 and 14 N., R. 27 E., iron post	1,017.74
Corner Ts. 13 and 14 N., Rs. 26 and 27 E., iron post	956
Closing corner T. 12 N., Rs. 26 and 27 E., iron post	590.308
Standard corner T. 13 N., Rs. 26 and 27 E., iron post	657.058
Arkansas-Choctaw boundary line, closing corner Ts. 12 and 13 N., R. 27 E., iron post	700.888

TAHLEQUAH QUADRANGLE.

The railroad levels were run by Messrs. E. L. Faison, W. S. D. Moore, and R. Coe. Mr. W. S. D. Moore had an independent level party. Mr. J. H. Carlock was attached to the subdivision and topographic party of Mr. C. W. Goodlove; Mr. J. P. Walker to Mr. J. Ahern's party; and Messrs. H. L. Muldrow, W. S. D. Moore, H. M. Tidwell, H. H. Hellen, and D. Hannegan ran levels for Mr. R. H. McKee's party.

FROM MARBLE, ALONG THE KANSAS CITY, PITTSBURG AND GULF RAILROAD, TO WESTVILLE.

	Feet.
Marble, 2 miles south of; intersection of railroad with third standard parallel north, R. 23 E., near railroad mile pole 283, iron post	635.527
Marble, 1 mile north of; intersection of railroad with township line, T. 13 N., Rs. 23 and 24 E., near railroad mile pole 280, iron post	639.991
Bunch, 1¼ miles south of; on northwest corner of south abutment, bridge over Sallisaw Creek	734.515
Kenedy's siding, 2 miles north of; intersection of railroad with township line, Ts. 14 and 15 N., R. 24 E., 1,000 feet south of railroad mile pole 268, iron post	838.17
Stilwell; square hole cut in northeast corner of foundation stone of coal schute	1,106.048
Barren, 2 miles south of; intersection of railroad with fourth standard parallel, 45 feet west of quarter corner of sec. 34, T. 17 N., R. 25 E., 660 feet north of mile pole 252, iron post	924.316
Barren, ½ mile south of; northwest anchor bolt, on last coping stone of north abutment, bridge over Barren Fork	876.073
Westville; intersection of railroad and township line, Ts. 17 and 18 N., R. 26 E., 1,480 feet north of mile pole 245, and 1,790 feet south of Westville station, iron post	1,124.442

ALONG TOWNSHIP LINES.

	Feet.
Corner Ts. 17 and 18 N., Rs. 22 and 23 E., iron post	729.011
Corner Ts. 17 and 18 N., Rs. 23 and 24 E., iron post	1,030.411
Corner Ts. 17 and 18 N., Rs. 24 and 25 E., iron post	1,107.151
Corner Ts. 17 and 18 N., Rs. 25 and 26 E., iron post	1,123.833
Arkansas-Choctaw boundary line, closing corner Ts. 17 and 18 N., R. 26 E., iron post	1,176.843
Arkansas-Choctaw boundary line, closing corner fourth standard parallel, R. 26 E., iron post	1,119.296
Standard corner T. 17 N., Rs. 25 and 26 E., iron post	1,078.946
Closing corner T. 16 N., Rs. 25 and 26 E., iron post	1,130.766
Standard corner T. 17 N., Rs. 24 and 25 E., iron post	1,156.445
Closing corner T. 16 N., Rs. 24 and 25 E., iron post	1,074.095
Standard corner T. 17 N., Rs. 23 and 24 E., iron post	1,085.815
Closing corner T. 16 N., Rs. 23 and 24 E., iron post	1,060.815
Standard corner T. 17 N., Rs. 22 and 23 E., iron post	892.772
Closing corner T. 16 N., Rs. 22 and 23 E., iron post	921.739
Witness corner to Ts. 15 and 16 N., Rs. 22 and 23 E., iron post	623.736
Corner Ts. 15 and 16 N., Rs. 23 and 24 E., iron post	982.496
Corner Ts. 15 and 16 N., Rs. 24 and 25 E., iron post	1,019.158
Corner Ts. 15 and 16 N., Rs. 25 and 26 E., iron post	1,111.968
Corner Ts. 14 and 15 N., Rs. 25 and 26 E., iron post	1,226.88
Corner Ts. 14 and 15 N., Rs. 24 and 25 E., iron post	1,353.76
Corner Ts. 14 and 15 N., Rs. 23 and 24 E., iron post	1,015.062
Corner Ts. 14 and 15 N., Rs. 22 and 23 E., iron post	804.762
Corner Ts. 13 and 14 N., Rs. 22 and 23 E., iron post	1,283.271
Corner Ts. 13 and 14 N., Rs. 23 and 24 E., iron post	766.501
Corner Ts. 13 and 14 N., Rs. 24 and 25 E., iron post	1,174.571
Corner Ts. 13 and 14 N., Rs. 25 and 26 E., iron post	802.851
Standard corner T. 13 N., Rs. 25 and 26 E., iron post	760.628
Closing corner T. 12 N., Rs. 25 and 26 E., iron post	694.128
Standard corner T. 13 N., Rs. 24 and 25 E., iron post	887.194
Closing corner T. 12 N., Rs. 24 and 25 E., iron post	798.308
Standard corner T. 13 N., Rs. 23 and 24 E., iron post	721.787
Closing corner T. 12 N., Rs. 23 and 24 E., iron post	639.786
Standard corner T. 13 N., Rs. 22 and 23 E., iron post	564.678
Closing corner T. 12 N., Rs. 22 and 23 E., iron post	711.482

MUSCOGEE QUADRANGLE.

The railroad levels were run by Messrs. R. Coe, G. A. Purington, A. F. Hassan, J. Phelan, and C. B. Odell. Messrs. W. S. D. Moore, C. B. Odell, A. F. Hassan, E. M. Fry, and E. L. Faison had charge of independent parties. Messrs. George Nick and J. P. Walker were attached to the subdivision and topographic party of Mr. Jeremiah Ahern, while Messrs. H. L. Muldrow, H. H. Hellen, and W. S. D. Moore were attached to that of Mr. R. H. McKee.

FROM CHECOTAH, ALONG THE MISSOURI, KANSAS AND TEXAS RAILWAY, TO WAGONER.

	Feet.
Checotah, ½ mile north of; cottonwood tree 60 feet left of line and 100 feet north of mile pole 525	637.201

	Feet.
Oktaha, 2 miles south of; copper bolt in natural ledge of stone 84.5 feet west of track and 1,815 feet south of mile pole 519; opposite old water tank foundation	551.745
Oktaha, spike in first telegraph pole south of mile pole 517	591.278
Summit, 1½ miles south of; copper bolt set 8 inches from east edge of the east coping stone of south pier, bridge 273	570.745
Summit, spike in mile pole 510	601.786
Muscogee, iron post at southeast corner of Hotel Adams lawn, 24.3 feet from railroad and 19.7 feet from hotel	599.829
Muscogee, bronze tablet in second course of stone above sidewalk of First National Bank building, left of entrance	608.618
Wybark, 1 mile south of; square hole cut into top stone on east side of ballast wall, south abutment Missouri, Kansas and Texas Railway bridge over Arkansas River	527.559
Blackstone, ½ mile north of; copper bolt sunk into coping stone of east side of south abutment of bridge over Verdigris River	518.941
Gibson station, ½ mile south of; square hole cut into west coping stone of north abutment of bridge south of mile pole 493	535.302
Wagoner, copper bolt sunk into stone, 54 feet north of the intersection of the Missouri, Kansas and Texas and St. Louis, Iron Mountain and Southern railroads	578.472

FROM ILLINOIS ALONG THE ST. LOUIS, IRON MOUNTAIN AND SOUTHERN RAILWAY TO WAGONER.

Illinois, 2 miles south of; copper bolt set into coping stone of north side of west pier of bridge over Illinois River	477.282
Illinois, 2½ miles north of; at the intersection of railroad and third standard parallel north; a sandstone post 18 by 18 by 15 inches, set between two small elm trees, which are 55.8 feet right of railroad	500.203
Braggs, 3 miles south of; nail in post oak tree 24 inches, 45 feet right of railroad	494.454
Braggs, 3 miles north of; copper bolt set into third coping stone of north end of east pier of bridge 104, which is 700 feet west of mile pole 567	502.315
Fort Gibson, 2½ miles south of; square hole cut into second coping stone of east pier of bridge 106 over Bayou Manard	510.732
Fort Gibson, 1 mile north of; copper bolt set into third coping stone of east pier of bridge over Grand River	515.515
Correta, 1 mile south of; nail in post oak 12 inches in diameter, 75 feet right of track, 300 feet east of mile pole 579	550.334
Correta, 1 mile north of; red oak 20 inches in diameter, 75 feet right of track, 90 feet north of mile pole 581	515.528
Wagoner, bronze tablet set into first course of stone, 2½ feet above sidewalk, and 8 inches from south corner of First National Bank Building	588.436

ALONG TOWNSHIP LINES.

Corner Ts. 17 and 18 N., Rs. 17 and 18 E., iron post	555.162
Corner Ts. 17 and 18 N., Rs. 18 and 19 E., iron post	545.261
Corner Ts. 17 and 18 N., Rs. 19 and 20 E., iron post	691.926
Corner Ts. 17 and 18 N., Rs. 20 and 21 E., iron post	676.141
Corner Ts. 17 and 18 N., Rs. 21 and 22 E., iron post	928.561
Standard corner T. 17 N., Rs. 21 and 22 E., iron post	798.569
Closing corner T. 16 N., Rs. 21 and 22 E., iron post	814.089
Standard corner T. 17 N., Rs. 20 and 21 E., iron post	811.423

	Feet.
Closing corner T. 16 N., Rs. 20 and 21 E., iron post	756.873
Standard corner T. 17 N., Rs. 19 and 20 E., iron post	679.989
Standard corner T. 17 N., Rs. 18 and 19 E., iron post	565.105
Standard corner T. 17 N., 17 and 18 E., iron post	513.175
Corner Ts. 15 and 16 N., Rs. 17 and 18 E., iron post	608.222
Corner Ts. 15 and 16 N., Rs. 18 and 19 E., iron post	515.2
Corner Ts. 15 and 16 N., Rs. 19 and 20 E., iron post	601.499
Corner Ts. 15 and 16 N., Rs. 20 and 21 E., iron post	666.365
Corner Ts. 15 and 16 N., Rs. 21 and 22 E., iron post	832.446
Corner Ts. 14 and 15 N., Rs. 21 and 22 E., iron post	768.502
Corner Ts. 14 and 15 N., Rs. 20 and 21 E., iron post	660.562
Corner Ts. 14 and 15 N., Rs. 18 and 19 E., iron post	560.152
Corner Ts. 14 and 15 N., Rs. 17 and 18 E., iron post	626.22
Corner Ts. 13 and 14 N., Rs. 17 and 18 E., iron post	612.19
Corner Ts. 13 and 14 N., Rs. 18 and 19 E., iron post	570.19
Corner Ts. 13 and 14 N., Rs. 20 and 21 E., iron post	776.77
Corner Ts. 13 and 14 N., Rs. 21 and 22 E., iron post	527.22
Standard corner T. 13 N., Rs. 21 and 22 E., iron post	828.09
Closing corner T. 12 N., Rs. 21 and 22 E., iron post	799.96
Standard corner T. 13 N., Rs. 20 and 21 E., iron post	613.94
Closing corner T. 12 N., Rs. 20 and 21 E., iron post	504.08
Standard corner T. 13 N., Rs. 19 and 20 E., iron post	533.04
Closing corner T. 12 N., Rs. 19 and 20 E., iron post	544.09
Standard corner T. 13 N., Rs. 18 and 19 E., iron post	510.01
Closing corner T. 12 N., Rs. 18 and 19 E., iron post	512.75
Standard corner T. 13 N., Rs. 17 and 18 E., iron post	708.64
Closing corner T. 12 N., Rs. 17 and 18 E., iron post	733.7

OKMULGEE QUADRANGLE.

No railroad levels were run in this quadrangle. Messrs. W. S. Moore, C. B. Odell, A. F. Hassan, E. M. Fry, E. H. Lonsdale, and E. L. Faison had charge of independent level parties.

ALONG TOWNSHIP LINES.

	Feet.
Corner Ts. 17 and 18 N., Rs. 12 and 13 E., iron post	720.067
Corner Ts. 17 and 18 N., Rs. 13 and 14 E., iron post	618.257
Corner Ts. 17 and 18 N., Rs. 14 and 15 E., iron post	629.297
Corner Ts. 17 and 18 N., Rs. 15 and 16 E., iron post	723.357
Corner Ts. 17 and 18 N., Rs. 16 and 17 E., iron post	524.007
Standard corner T. 17 N., Rs. 16 and 17 E., iron post	604.495
Standard corner T. 17 N., Rs. 15 and 16 E., iron post	565.459
Standard corner T. 17 N., Rs. 14 and 15 E., iron post	704.2
Standard corner T. 17 N., Rs. 13 and 14 E., iron post	597.175
Standard corner T. 17 N., Rs. 12 and 13 E., iron post	711.175
Corner Ts. 15 and 16 N., Rs. 12 and 13 E., iron post	716.168
Corner Ts. 15 and 16 N., Rs. 13 and 14 E., iron post	654.172
Corner Ts. 15 and 16 N., Rs. 14 and 15 E., iron post	670.174
Corner Ts. 15 and 16 N., Rs. 15 and 16 E., iron post	562.187
Corner Ts. 15 and 16 N., Rs. 16 and 17 E., iron post	567.268
Corner Ts. 14 and 15 N., Rs. 16 and 17 E., iron post	650.174
Corner Ts. 14 and 15 N., Rs. 15 and 16 E., iron post	607.19
Corner Ts. 14 and 15 N., Rs. 14 and 15 E., iron post	671.174
Corner Ts. 14 and 15 N., Rs. 13 and 14 E., iron post	768.188

	Feet.
r Ts. 14 and 15 N., Rs. 12 and 13 E., iron post	885.166
r Ts. 13 and 14 N., Rs. 12 and 13 E., iron post	678.227
r Ts. 13 and 14 N., Rs. 13 and 14 E., iron post	698.195
r Ts. 13 and 14 N., Rs. 14 and 15 E., iron post	658.198
r Ts. 13 and 14 N., Rs. 15 and 16 E., iron post	635.197
r Ts. 13 and 14 N., Rs. 16 and 17 E., iron post	680.855
ard corner T. 13 N., Rs. 16 and 17 E., iron post	611.863
ıg corner T. 12 N., Rs. 16 and 17 E., iron post	616.846
ard corner T. 13 N., Rs. 15 and 16 E., iron post	644.858
ıg corner T. 12 N., Rs. 15 and 16 E., iron post	639.823
ard corner T. 13 N., Rs. 14 and 15 E., iron post	805.861
ıg corner T. 12 N., Rs. 14 and 15 E., iron post	742.85
ard corner T. 13 N., Rs. 13 and 14 E., iron post	660.86
ıg corner T. 12 N., Rs. 13 and 14 E., iron post	648.866
ard corner T. 13 N., Rs. 12 and 13 E., iron post	789.952
ıg corner T. 12 N., Rs. 12 and 13 E., iron post	807.215

NUYAKA QUADRANGLE.

.e levels in this quadrangle were run by several independent par- under Messrs. W. S. D. Moore, W. R. Manning, A. F. Hassan, [. Fry, E. L. Faison, C. B. Odell, and E. H. Lonsdale.

ALONG TOWNSHIP LINES.

	Feet.
ır Ts. 17 and 18 N., Rs. 8 and 9 E., iron post	831.885
ır Ts. 17 and 18 N., Rs. 11 and 12 E., iron post	649.175
ard corner T. 17 N., Rs. 11 and 12 E., iron post	881.175
ıg corner T. 16 N., Rs. 11 and 12 E., iron post	843.027
ard corner T. 17 N., Rs. 10 and 11 E., iron post	767.137
ıg corner T. 16 N., Rs. 10 and 11 E., iron post	699.285
ıg corner T. 16 N., Rs. 9 and 10 E., iron post	758.305
ard corner T. 17 N., Rs. 8 and 9 E., iron post	923.309
ır Ts. 15 and 16 N., Rs. 8 and 9 E., iron post	780.763
ır Ts. 15 and 16 N., Rs. 9 and 10 E., iron post	757.385
ır Ts. 15 and 16 N., Rs. 10 and 11 E., iron post	969.152
ır Ts. 15 and 16 N., Rs. 11 and 12 E., iron post	792.165
ır Ts. 14 and 15 N., Rs. 11 and 12 E., iron post	831.169
ır Ts. 14 and 15 N., Rs. 10 and 11 E., iron post	726.351
ır Ts. 14 and 15 N., Rs. 9 and 10 E., iron post	798.297
ır Ts. 14 and 15 N., Rs. 8 and 9 E., iron post	845.11
ır Ts. 13 and 14 N., Rs. 8 and 9 E., iron post	717.728
ır Ts. 13 and 14 N., Rs. 9 and 10 E., iron post	756.488
ır Ts. 13 and 14 N., Rs. 10 and 11 E., iron post	673.398
ır Ts. 13 and 14 N., Rs. 11 and 12 E., iron post	869.598
ard corner T. 13 N., Rs. 11 and 12 E., iron post	841.561
ard corner T. 13 N., Rs. 10 and 11 E., iron post	748.85
ard corner T. 13 N., Rs. 9 and 10 E., iron post	782.842
ard corner T. 13 N., Rs. 8 and 9 E., iron post	876.842

WEWOKA QUADRANGLE.

ıe railroad levels were run by Mr. E. L. Faison. Messrs. W. S. D. re, W. R. Manning, and E. L. Faison had independent level ies.

FROM HOLDENVILLE, ALONG THE CHOCTAW, OKLAHOMA AND GULF RAILROAD, TO WEWOKA.

	Feet.
Holdenville, 5 miles east of; square hole cut in large stone 30 feet south of track and 35 feet east of trestle No. 154	813.659
Holdenville; iron post at northwest corner of platform, 75 feet west of station building and 15 feet north of track	862.744
Wewoka; iron post south of track, 5 feet east of mile pole No, 99 and 2,400 feet west of station building	786.277

ALONG TOWNSHIP LINES.

Corner Ts. 11 and 12 N., Rs. 8 and 9 E., iron post	896.074
Corner Ts. 11 and 12 N., Rs. 9 and 10 E., iron post	903.553
Corner Ts. 11 and 12 N., Rs. 10 and 11 E., iron post	889.942
Corner Ts. 11 and 12 N., Rs. 11 and 12 E., iron post	716.135
Corner Ts. 10 and 11 N., Rs. 11 and 12 E., iron post	726.32
Corner Ts. 10 and 11 N., Rs. 10 and 11 E., iron post	893.388
Corner Ts. 10 and 11 N., Rs. 9 and 10 E., iron post	855.052
Corner Ts. 10 and 11 N., Rs. 8 and 9 E., iron post	826.052
Corner Ts. 9 and 10 N., Rs. 8 and 9 E., iron post	846.839
Corner Ts. 9 and 10 N., Rs. 9 and 10 E., iron post	855.908
Corner Ts. 9 and 10 N., Rs. 10 and 11 E., iron post	748.966
Corner Ts. 9 and 10 N., Rs. 11 and 12 E., iron post	733.106
Standard corner, T. 9 N., Rs. 11 and 12 E., iron post	832.855
Standard corner, T. 9 N., Rs. 10 and 11 E., iron post	787.233
Standard corner, T. 9 N., Rs. 9 and 10 E., iron post	734.165
Standard corner, T. 9 N., Rs. 8 and 9 E., iron post	847.189
Corner Ts. 7 and 8 N., Rs 8 and 9 E., iron post	798.729
Corner Ts. 7 and 8 N., Rs. 9 and 10 E., iron post	866.892
Corner Ts. 7 and 8 N., Rs. 10 and 11 E., iron post	921.165
Corner Ts. 7 and 8 N., Rs. 11 and 12 E., iron post	811.812
Corner Ts. 6 and 7 N., Rs. 11 and 12 E., iron post	854.793
Corner Ts. 6 and 7 N., Rs. 10 and 11 E., iron post	827.787
Corner Ts. 6 and 7 N., Rs. 9 and 10 E., iron post	800.811
Corner Ts. 6 and 7 N., Rs. 8 and 9 E., iron post	752.823

CANADIAN QUADRANGLE.

The railroad levels were run by Mr. G. A. Purington. Messrs. E. L. Faison, W. R. Manning, and W. S. D. Moore had independent level parties. Messrs. George Nick and J. P. Walker were attached to the topographic and subdivision party of Mr. Jeremiah Ahern, while Messrs. Moore and Purington were attached for a short time to that of Mr. W. B. Corse.

FROM M'ALESTER, ALONG THE MISSOURI, KANSAS AND TEXAS RAILWAY, TO CHECOTAH.

	Feet.
McAlester, 3 miles north of; nail in post oak 36 inches in diameter, 50 feet right of track and 1,100 feet south of mile pole 561	623.557
Reams, ½ mile south of; copper bolt sunk into first coping stone of northeast abutment of trestle 317, 3,000 feet north of mile pole 556	612.067
Reams; on "head block" of north end of siding	595.3

	Feet.
Reams, 5 miles north of; copper bolt set into stone on northeast abutment, north end of trestle 310, which is the first trestle south of mile pole 550..	609.022
South Canadian, ¼ mile north of; nail in root of black jack oak, 24 inches in diameter, 60 feet left of track and 60 feet north of mile pole 547.....	654.873
South Canadian, 3⅜ miles north of; copper bolt set into first coping stone of northwest abutment bridge 304, which spans the South Canadian River.	556.558
Eufaula; 1,000 feet north of station building, red oak, 12 inches in diameter, 50 feet left of track and 140 feet north of mile pole 538.....	617.219
Eufaula, 2 miles north of; copper bolt set into first coping stone on northwest abutment of bridge 298, which spans the North Canadian River ..	549.439
Bond; copper bolt set into stone on northwest side of stone culvert, north of section house 75 and 90 feet north of switch	661.031
Checotah, ⅓ mile south of; nail in cottonwood tree 60 feet left of track and 100 feet north of mile pole 525.....	637.201

ALONG TOWNSHIP LINES.

Corner Ts. 11 and 12 N., Rs. 12 and 13 E., iron post.....	872.835
Corner Ts. 11 and 12 N., Rs. 13 and 14 E., iron post.....	593.88
Corner Ts. 11 and 12 N., Rs. 14 and 15 E., iron post.....	757.826
Corner Ts. 11 and 12 N., Rs. 15 and 16 E., iron post.....	659.538
Corner Ts. 11 and 12 N., Rs. 16 and 17 E., iron post.....	640.989
Corner Ts. 10 and 11 N., Rs. 16 and 17 E., iron post.....	629.512
Corner Ts. 10 and 11 N., Rs. 15 and 16 E., iron post.....	608.978
Corner Ts. 10 and 11 N., Rs. 14 and 15 E., iron post.....	631.342
Corner Ts. 10 and 11 N., Rs. 13 and 14 E., iron post.....	663.469
Corner Ts. 10 and 11 N., Rs. 12 and 13 E., iron post.....	735.478
Corner Ts. 9 and 10 N., Rs. 12 and 13 E., iron post.....	803.885
Corner Ts. 9 and 10 N., Rs. 13 and 14 E., iron post.....	715.269
Corner Ts. 9 and 10 N., Rs. 14 and 15 E., iron post.....	672.545
Corner Ts. 9 and 10 N., Rs. 15 and 16 E., iron post.....	630.256
Corner Ts. 9 and 10 N., Rs. 16 and 17 E., iron post.....	565.803
Standard corner T. 9 N., Rs. 16 and 17 E., iron post.....	562.048
Standard corner T. 9 N., Rs. 15 and 16 E., iron post.....	604.909
Standard corner T. 9 N., Rs. 14 and 15 E., iron post.....	675.827
Standard corner T. 9 N., Rs. 13 and 14 E., iron post.....	694.866
Standard corner T. 9 N., Rs. 12 and 13 E., iron post.....	720.91
Corner Ts. 7 and 8 N., Rs. 12 and 13 E., iron post.....	838.844
Corner Ts. 7 and 8 N., Rs. 13 and 14 E., iron post.....	702.795
Corner Ts. 7 and 8 N., Rs. 14 and 15 E., iron post.....	651.81
Corner Ts. 7 and 8 N., Rs. 15 and 16 E., iron post.....	717.276
Corner Ts. 7 and 8 N., Rs. 16 and 17 E., iron post.....	760.818
Corner Ts. 6 and 7 N., Rs. 16 and 17 E., iron post.....	761.818
Corner Ts. 6 and 7 N., Rs. 15 and 16 E., iron post.....	557.947
Corner Ts. 6 and 7 N., Rs. 14 and 15 E., iron post.....	880.861
Corner Ts. 6 and 7 N., Rs. 13 and 14 E., iron post.....	657.959
Corner Ts. 6 and 7 N., Rs. 12 and 13 E., iron post.....	766.841

SANSBOIS QUADRANGLE.

No levels were run by railroad or independent parties. Messrs. G. A. Purington and W. S. D. Moore were attached to the subdivision and topographic party of Mr. W. B. Corse (relieved by Mr. Farmer), and Messrs. George Nick and J. P. Walker to Mr. J. Ahern's party.

ALONG TOWNSHIP LINES.

	Fe
Corner Ts. 11 and 12 N., Rs. 17 and 18 E., iron post	656.
Corner Ts. 11 and 12 N., Rs. 18 and 19 E., iron post	588.
Corner Ts. 11 and 12 N., Rs. 19 and 20 E., iron post	557.
Corner Ts. 11 and 12 N., Rs. 20 and 21 E., iron post	470.
Corner Ts. 11 and 12 N., Rs. 21 and 22 E., iron post	518.
Corner Ts. 10 and 11 N., Rs. 21 and 22 E., iron post	560.
Corner Ts. 10 and 11 N., Rs. 20 and 21 E., iron post	468.
Corner Ts. 10 and 11 N., Rs. 19 and 20 E., iron post	560.
Corner Ts. 10 and 11 N., Rs. 18 and 19 E., iron post	872.
Corner Ts. 10 and 11 N., Rs. 17 and 18 E., iron post	586.
Corner Ts. 9 and 10 N., Rs. 17 and 18 E., iron post	871.
Corner Ts. 9 and 10 N., Rs. 18 and 19 E., iron post	815.
Corner Ts. 9 and 10 N., Rs. 19 and 20 E., iron post	516.
Corner Ts. 9 and 10 N., Rs. 20 and 21 E., iron post	541.
Corner Ts. 9 and 10 N., Rs. 21 and 22 E., iron post	605.
Standard corner T. 9 N., Rs. 21 and 22 E., iron post	473.
Closing corner T. 8 N., Rs. 21 and 22 E., iron post	477.
Standard corner T. 9 N., Rs. 20 and 21 E., iron post	682.
Closing corner T. 8 N., Rs. 20 and 21 E., iron post	706.
Standard corner T. 9 N., Rs. 19 and 20 E., iron post	627.
Closing corner T. 8 N., Rs. 19 and 20 E., iron post	655.
Standard corner T. 9 N., Rs. 18 and 19 E., iron post	901.
Closing corner T. 8 N., Rs. 18 and 19 E., iron post	937.
Standard corner T. 9 N., Rs. 17 and 18 E., iron post	834.
Closing corner T. 8 N., Rs. 17 and 18 E., iron post	840.
Corner Ts. 7 and 8 N., Rs. 17 and 18 E., iron post	915.
Corner Ts. 7 and 8 N., Rs. 18 and 19 E., iron post	616.
Corner Ts. 7 and 8 N., Rs. 19 and 20 E., iron post	532.
Corner Ts. 7 and 8 N., Rs. 20 and 21 E., iron post	620.
Corner Ts. 7 and 8 N., Rs. 21 and 22 E., iron post	602.
Corner Ts. 6 and 7 N., Rs. 21 and 22 E., iron post	801.
Corner Ts. 6 and 7 N., Rs. 20 and 21 E., iron post	831.
Corner Ts. 6 and 7 N., Rs. 19 and 20 E., iron post	948.
Corner Ts. 6 and 7 N., Rs. 18 and 19 E., iron post	1,293.
Corner Ts. 6 and 7 N., Rs. 17 and 18 E., iron post	900.

SALLISAW QUADRANGLE.

The railroad levels were run by Messrs. R. Coe, G. A. Purington, E. Faison, E. M. Fry, C. H. Hickman, and J. W. Phelan. Mr. J. H. C lock was attached to the subdivision and topographic party of I C. W. Goodlove; Messrs. J. P. Walker and D. Voorhees to that Mr. J. Ahern, and Messrs. E. M. Fry and G. A. Purington to that Mr. R. A. Farmer.

FROM SALLISAW, ALONG THE KANSAS CITY, PITTSBURG AND GULF RAILROAD, TO POTEAU.

	Fe
Sallisaw; iron post set at south end of platform, east of track, at Kansas City, Pittsburg and Gulf Railroad station	524.
Sallisaw, 4 miles south of; intersection of railroad with sixth guide meridian east; iron post set in line of telegraph poles, 3,000 feet north of *mile* pole 295	567.

	Feet.
Gans, ½ mile south of; the intersection of railroad with township line, Ts. 10 and 11 N., R. 25 E.; iron post set in line of telegraph poles, 35 feet west of track	481.56
Redland, ½ mile south of; intersection of railroad with township line, Ts. 9 and 10 N., R. 25 E., iron post 15 feet west of track	430.633
Oak Lodge, 2½ miles south of; intersection of railroad with second standard parallel north, R. 25 E., spike in white oak (blazed and marked), 50 feet west of track	474.72
Shady Point, ½ mile south of; intersection of township line, Ts. 7 and 8 N., R. 25 E., 100 feet south of mile pole 321, and 60 feet west of track; iron post	427.565
Poteau; iron post set at south end of station platform, 36 feet west of main track	457.005
Poteau, 1¾ miles south of; intersection of railroad with township line, Ts. 6 and 7 N., R. 25 E.; water oak, 60 feet west of track	441.805

FROM CAMERON, ALONG THE ST. LOUIS AND SAN FRANCISCO RAILROAD, TO POTEAU.

Cameron; copper bolt in stone monument 57 feet east of track and 60 feet north of station building. Monument is referenced by a stone 12 feet north and one 12 feet east	487.591
Cameron; bronze tablet set into fifth stone above foundation course at southeast corner of building owned by Mrs. F. H. Carr, and used as a general store and post-office building, is 170 feet west of the St. Louis and San Francisco track, and 27 feet south of a prolonged line of the south end of the station building	487.518
Cameron, 5 miles south of; hickory tree 12 inches in diameter, 60 feet left of track and 260 feet north of mile pole 441	445.479
Poteau, 2 miles south of; "twin" post oak, 70 feet right of track and 800 feet south of mile pole 447	505.496

FROM CHEROKEE, ALONG THE ST. LOUIS, IRON MOUNTAIN AND SOUTHERN RAILWAY, TO VIAN.

Cherokee, 5 miles west of; at bridge 26, spike in black oak, 15 inches in diameter, 70 feet left of track	480.746
Muldrow; sandstone post, 2 by 6 by 6 inches, marked B + M, buried 6 inches below surface, 71.3 feet from northeast corner of station building and 30 feet from "mail grab"	510.846
Hanson; spike in red oak 4 inches in diameter, 100 feet left of track	568.741
Sallisaw; sandstone post, 2 by 8 by 5 inches, marked $\frac{\text{U.S.G.S.}}{\text{B + M}}$, buried south of station building, 40.6 feet from southeast and 44.8 feet from southwest corners of same	530.188
McKey, spike in red oak 8 inches in diameter, 60 feet right of track	536.086
Vian; sandstone post, 28 by 8 by 4 inches, marked $\frac{\text{U.S.G.S.}}{\text{B + M}}$, buried 6 inches beneath the surface, south of station building, 31 7 feet from southwest and 36.7 feet from southeast corners of same	545.598

ALONG TOWNSHIP LINES.

Corner Ts. 11 and 12 N., Rs. 22 and 23 E., iron post	478.108
Corner Ts. 11 and 12 N., Rs. 23 and 24 E., iron post	550.394
Corner Ts. 11 and 12 N., Rs. 24 and 25 E., iron post	532.858

	Feet.
Corner Ts. 11 and 12 N., Rs. 25 and 26 E., iron post	684.998
Corner Ts. 10 and 11 N., Rs. 25 and 26 E., iron post	477.675
Corner Ts. 10 and 11 N., Rs. 24 and 25 E., iron post	564.89
Corner Ts. 10 and 11 N., Rs. 23 and 24 E., iron post	494.963
Corner Ts. 10 and 11 N., Rs. 22 and 23 E., iron post	445.628
Corner Ts. 9 and 10 N., Rs. 22 and 23 E., iron post	458.547
Corner Ts. 9 and 10 N., Rs. 23 and 24 E., iron post	603.999
Corner Ts. 9 and 10 N., Rs. 24 and 25 E., iron post	440.093
Corner Ts. 9 and 10 N., Rs. 25 and 26 E., iron post	423.723
Closing corner T. 8 N., Rs. 26 and 27 E., iron post	622.37
Standard corner T. 9 N., Rs. 25 and 26 E., iron post	437.53
Closing corner T. 8 N., Rs. 25 and 26 E., iron post	440.51
Standard corner T. 9 N., Rs. 24 and 25 E., iron post	570.324
Closing corner T. 8 N., Rs. 24 and 25 E., iron post	562.334
Standard corner T. 9 N., Rs. 23 and 24 E., iron post	553.614
Closing corner T. 8 N., Rs. 23 and 24 E., iron post	540.374
Standard corner T. 9 N., Rs. 22 and 23 E., iron post	693.454
Closing corner T. 8 N., Rs. 22 and 23 E., iron post	633.544
Corner Ts. 7 and 8 N., Rs. 22 and 23 E., iron post	655.747
Corner Ts. 7 and 8 N., Rs. 23 and 24 E., iron post	466.057
Corner Ts. 7 and 8 N., Rs. 24 and 25 E., iron post	519.767
Corner Ts. 7 and 8 N., Rs. 25 and 26 E., iron post	424.187
Corner Ts. 7 and 8 N., Rs. 26 and 27 E., iron post	521.032
Corner Ts. 6 and 7 N., Rs. 26 and 27 E., iron post	583.406
Corner Ts. 6 and 7 N., Rs. 25 and 26 E., iron post	443.266
Corner Ts. 6 and 7 N., Rs. 24 and 25 E., iron post	711.136
Corner Ts. 6 and 7 N., Rs. 23 and 24 E., iron post	1,287.856
Corner Ts. 6 and 7 N., Rs. 22 and 23 E., iron post	511.336

FORT SMITH QUADRANGLE (INDIAN TERRITORY-ARKANSAS).

The railroad levels were run by Messrs. R. Coe, C. H. Hickman, J. Phelan, and G. A. Purington. Mr. J. H. Carlock was attached to the subdivision and topographic party of Mr. C. W. Goodlove, and Mr. E. M. Fry to that of Mr. R. A. Farmer.

FROM FORT SMITH, ARKANSAS, ALONG THE ST. LOUIS AND SAN FRANCISCO RAILROAD, TO JENSON, ARKANSAS.

	Feet.
Fort Smith, Arkansas (bench mark established by United States Coast and Geodetic Survey); a copper bolt leaded in the west wall of United States jail (brick). The bolt is in the first course above the limestone base stone and about 1 meter above the ground. It is in the fifth brick from the panel formed by the side of the building and the brick ventilator. The jail is a new pressed-brick addition to the old United States building. A cross was cut in the end of the bolt, and the intersection of the lines forming the cross is the bench mark. The letters U. S. B. M. were in the base stone immediately below the bolt	446.29
Fort Smith, Arkansas, 5 miles south of; black oak 65 feet to the right of track and 190 feet north of milepole 420	478.696
Cedars, Indian Territory; elm 12 inches in diameter 45 feet left and 75 feet south of milepole 424	448.044
Jenson, Arkansas; square hole drilled into the north veranda post stone of stone building just back of station, which has been destroyed by fire.	545.11
Jenson, 4 miles south of; water oak 50 feet left of track and nearly opposite *milepole 433*	452.629

ALONG TOWNSHIP LINES.

	Feet.
Corner Ts. 11 and 12 N., Rs. 26 and 27 E., iron post	723.718
Arkansas-Choctaw boundary line, closing corner Ts. 11 and 12 N., R. 27 E., iron post	764.098
Arkansas-Choctaw boundary line, closing corner Ts. 10 and 11 N., R. 27 E., iron post	435.875
Corner Ts. 10 and 11 N., Rs. 26 and 27 E., iron post	418.425
Corner Ts. 9 and 10 N., Rs. 26 and 27 E., iron post	421.073
Arkansas-Choctaw boundary line, closing corner Ts. 9 and 10 N., R. 27 E., iron post	513.2
Arkansas boundary line, closing corner second standard parallel north, R. 27 E., iron post	555.16
Standard corner T. 9 N., Rs. 26 and 27 E., iron post	620.01
Arkansas-Choctaw boundary line, closing corner Ts. 7 and 8 N., R. 27 E., iron post	611.302
Arkansas-Choctaw boundary line, closing corner Ts. 6 and 7 N., R. 27 E., iron post	1,388.956

POTEAU MOUNTAIN QUADRANGLE (ARKANSAS-INDIAN TERRITORY).

Mr. E. M. Fry ran the railroad levels. Mr. W. P. Halliday was attached to the subdivision and topographic party of Mr. W. S. Post, and Mr. E. M. Fry to Mr. R. A. Farmer's party.

ON KANSAS CITY, PITTSBURG AND GULF RAILROAD.

	Feet.
Page, 5 miles south of; intersection of railroad with Arkansas-Choctaw boundary line, iron post	1,223.405

ALONG TOWNSHIP LINES.

Arkansas-Choctaw boundary line, closing corner Ts. 5 and 6 N., R. 27 E., iron post	1,615.97
Arkansas-Choctaw boundary line, closing corner Ts. 4 and 5 N., R. 27 E., corner stone	690.164
Arkansas-Choctaw boundary line, closing corner Ts. 1 N. and 1 S., R. 27 E., corner stone	948.219

WINDING STAIR QUADRANGLE.

Messrs. R. Coe, G. A. Purington, H. C. McCluer, and E. M. Fry ran the railroad levels. Mr. F. E. Fellows had an independent level party. Messrs. G. A. Purington and E. M. Fry were attached to the topographic and subdivision party of Mr. R. A. Farmer, and Messrs. W. P. Halliday and G. H. Bartlett to that of Mr. W. S. Post.

ALONG THE CHOCTAW, OKLAHOMA AND GULF RAILROAD, FROM WISTER TO FANSHAWE.

	Feet.
Wister; post oak, 24 inches in diameter, in the northeast angle of the Choctaw, Oklahoma and Gulf, and the St. Louis and San Francisco railroads, 150 feet from the Choctaw, Oklahoma and Gulf, and 350 feet from the St. Louis and San Francisco track	474.372

	Feet.
Wister, ½ mile west of; square hole in south coping stone of east abutment of bridge No. 1	480.908
Wister, 1½ miles west of; square hole in north coping stone of east abutment of bridge No. 7, 500 feet west of milepost 214	497.298
Fanshawe, 2 miles east of; square hole in north coping stone of east abutment of bridge near milepost 207	553.651
Fanshawe, ⅛ mile west of; red oak, 16 inches in diameter, 120 feet right of track and 100 feet west of milepost 205	554.486
Fanshawe, 3 miles west of; elm, 18 inches in diameter, 130 feet right and 200 feet west of milepost 202	543.944

ALONG THE ST. LOUIS AND SAN FRANCISCO RAILROAD FROM CAVANAL TO LEFLORE.

Cavanal; post oak, 24 inches in diameter, 180 feet left of track, nearly opposite milepost 451	468.963
Wister, ½ mile west of; square hole cut into south coping stone of east pier of bridge 237 T	472.701
Wister, 1 mile southwest of; black oak, 8 inches in diameter, 150 feet south and 75 feet east of milepost 454	478.136
Caston; white oak, 30 inches in diameter, 60 feet right of track, opposite milepost 456	494.889
Pocahontas; red oak, 20 inches in diameter, 120 feet north and 100 west of milepost 458	562.022
Folsom; white oak 16 inches in diameter, 100 feet south of track, opposite milepost 463	490.631
Leflore; elm 10 inches in diameter, 90 feet south and 100 feet east of station building	532.477

ALONG THE KANSAS CITY, PITTSBURG AND GULF RAILROAD FROM HEAVENER TO PAGE.

Heavener, 2 miles north of; at the intersection of the railroad with the north boundary of T. 5 N., R. 25 E., iron post	512.224
Heavener, 1 mile north of; copper bolt set into east coping stone of north abutment bridge over drain	565.278
Heavener, 1 mile south of; 650 feet south of milepost 338, iron post	553.226
Houston, 3 miles north of; at the intersection of the railroad with the first standard parallel north, near milepost 342, iron post	504.338
Houston, ⅛ mile south of; copper bolt set into east coping stone of north abutment bridge over drain	540.341
Thomasville, ⅛ mile south of; copper bolt set into west coping stone of north abutment bridge over creek	656.966
Page, ½ mile south of; root of a basswood 16 inches in diameter and 60 feet west of track and 35 feet south of mile-pole 355	927.355

ALONG TOWNSHIP LINES.

Corner Ts. 5 and 6 N., Rs. 26 and 27 E., iron post	980.967
Corner Ts. 5 and 6 N., Rs. 25 and 26 E., iron post	499.297
Corner Ts. 5 and 6 N., Rs. 24 and 25 E., iron post	456.937
Corner Ts. 5 and 6 N., Rs. 23 and 24 E., iron post	521.117
Corner Ts. 5 and 6 N., Rs. 22 and 23 E., iron post	551.271
Closing corner T. 4 N., Rs. 22 and 23 E., on stone	913.544
Standard corner T. 5 N., Rs. 22 and 23 E., iron post	722.694
Closing corner T. 4 N., Rs. 23 and 24 E., iron post	586.036

	Feet
Standard corner T. 5 N., Rs. 23 and 24 E., on stone	640.234
Closing corner T. 4 N., Rs. 24 and 25 E., on stone	575.924
Standard corner T. 5 N., Rs. 24 and 25 E., iron post	541.044
Closing corner T. 4 N., Rs. 25 and 26 E., iron post	507.544
Standard corner T. 5 N., Rs. 25 and 26 E., iron post	503.334
Closing corner T. 4 N., Rs. 26 and 27 E., iron post	566.264
Standard corner T. 5 N., Rs. 26 and 27 E., iron post	577.884
Corner Ts. 3 and 4 N., Rs. 26 and 27 E., iron post	703.372
Corner Ts. 3 and 4 N., Rs. 25 and 26 E., iron post	598.842
Corner Ts. 3 and 4 N., Rs. 24 and 25 E., iron post	951.786
Corner Ts. 3 and 4 N., Rs. 23 and 24 E., iron post	1,172.571
Corner Ts. 3 and 4 N., Rs. 22 and 23 E., iron post	1,023.659
Corner Ts. 2 and 3 N., Rs. 22 and 23 E., iron post	641.008
Corner Ts. 2 and 3 N., Rs. 23 and 24 E., iron post	686.451
Corner Ts. 2 and 3 N., Rs. 24 and 25 E., iron post	910.872
Corner Ts. 2 and 3 N., Rs. 25 and 26 E., iron post	2,471.012
Corner Ts. 2 and 3 N., Rs. 26 and 27 E., iron post	1,271.821
Corner Ts. 1 and 2 N., Rs. 26 and 27 E., iron post	1,977.796
Corner Ts. 1 and 2 N., Rs. 25 and 26 E., iron post	1,922.366
Corner Ts. 1 and 2 N., Rs. 24 and 25 E., iron post	1,478.558
Corner Ts. 1 and 2 N., Rs. 23 and 24 E., iron post	1,279.457
Corner Ts. 1 and 2 N., Rs. 22 and 23 E., iron post	1,344.108
Closing corner T. 1 S., Rs. 22 and 23 E., iron post	1,394.063
Standard corner T. 1 N., Rs. 22 and 23 E., iron post	1,382.122
Closing corner T. 1 S., Rs. 23 and 24 E., iron post	1,635.612
Standard corner T. 1 N., Rs. 23 and 24 E., iron post	1,756.266
Triangulation station, base line, sec. 31, T. 1 N., R. 24 E., near southwest corner of the SW. ¼, white oak 10 inches diameter, same having been used as signal tree	1,989.063
Closing corner T. 1 S., Rs. 24 and 25 E., iron post	888.039
Standard corner T. 1 N., Rs. 24 and 25 E., iron post	874.773
Closing corner T. 1 S., Rs. 25 and 26 E., iron post	866.809
Standard corner T. 1 N., Rs. 25 and 26 E., on stone	896.989
Closing corner T. 1 S., Rs. 26 and 27 E., iron post	940.459
Standard corner T. 1 N., Rs. 26 and 27 E., on stone	904.129

TUSKAHOMA QUADRANGLE.

Messrs. R. Coe, H. C. McCluer, and G. A. Purington ran the rai - road levels. Messrs. E. L. Faison and F. E. Fellows had independent level parties. Messrs. W. P. Halliday and G. H. Bartlett were attached to the topographic and subdivision party of Mr. W. S. Post, and Messrs. W. A. Correll, C. Doster, W. S. D. Moore, G. A. Purington, and E. M. Fry to the party of Mr. G. S. Smith, who was relieved by Mr. W. B. Corse, and he by Mr. R. A. Farmer.

ALONG THE ST. LOUIS AND SAN FRANCISCO RAILROAD FROM BENGAL TO STANLEY.

	Feet.
Bengal, ⅛ mile northeast of; red oak 15 inches diameter, 60 feet left of track and 210 feet south of milepost 475	626.67
Compton, ⅞ mile southwest of; near top of west end of north abutment of bridge 286, copper bolt	906.631

FROM HARTSHORNE, ALONG THE CHOCTAW, OKLAHOMA AND GULF RAILROAD, TO BARNETT.

	Feet.
Bridge 93; square hole cut into stone on south end of west abutment	645.66
Hartshorne; bronze tablet set into fourth stone above the foundation course, at the northeast corner of stone building owned by F. M. Savage, situated on Pennsylvania avenue, 125 feet west of west line of Fifth street, 670 feet south of main line of railroad, and 2,500 feet east of post-office building	703.93
Hartshorne, 13 miles west of; copper bolt in north end of culvert, 650 feet west of mine No. 1	676.23
Hartshorne, 2 miles west of; copper bolt set into stone on north end of parapet wall of bridge 106	606.70
Alderson; copper bolt set into north end of west abutment of bridge 112	680.85
Alderson, 1 mile west of; square hole cut into stone on south end of west abutment of bridge 117, 75 feet east of mile pole 156	648.8
Krebs, ½ mile west of; square hole cut into stone on southeast corner of east abutment of bridge 124	718.1
McAlester, 6 miles west of; cross (+) mark on top stone of west pier of bridge 206, 150 feet west of mile pole 145	650.8
Barnett, ⅔ mile east of; bronze tablet set into southwest corner of top stone of west pier of bridge 198, 550 feet west of mile pole 141, 10 miles west of McAlester	701.1 *42*

ON ST. LOUIS AND SAN FRANCISCO RAILROAD.

Butler, 4 miles north of; nail in red oak, 8 inches diameter, 40 feet left of track and 60 feet north of mile pole 518, near the intersection of the railroad witht he base line	513.589

ALONG TOWNSHIP LINES.

Corner Ts. 5 and 6 N., Rs. 12 and 13 E., iron post	764.15
Corner Ts. 5 and 6 N., Rs. 13 and 14 E., iron post	623.978
Corner Ts. 5 and 6 N., Rs. 14 and 15 E., iron post	719.724
Corner Ts. 5 and 6 N., Rs. 15 and 16 E., iron post	602.946
Corner Ts. 5 and 6 N., Rs. 16 and 17 E., iron post	678.867
Standard corner T. 5 N., Rs. 16 and 17 E., iron post	668.363
Closing corner T. 4 N., Rs. 16 and 17 E., iron post	668.615
Standard corner T. 5 N., Rs. 15 and 16 E., iron post	623.839
Closing corner T. 4 N., Rs. 15 and 16 E., iron post	622.725
Standard corner T. 5 N., Rs. 14 and 15 E., iron post	794.655
Closing corner T. 4 N., Rs. 14 and 15 E., iron post	810.525
Standard corner T. 5 N., Rs. 13 and 14 E., iron post	782.853
Closing corner T. 4 N., Rs. 13 and 14 E., iron post	798.279
Standard corner T. 5 N., Rs. 12 and 13 E., iron post	705.382
Closing corner T. 4 N., Rs. 12 and 13 E., iron post	699.261
Corner Ts. 3 and 4 N., Rs. 12 and 13 E., iron post	781.088
Corner Ts. 3 and 4 N., Rs. 13 and 14 E., iron post	731.686
Corner Ts. 3 and 4 N., Rs. 14 and 15 E., iron post	787.461
Corner Ts. 3 and 4 N., Rs. 15 and 16 E., iron post	759.212
Corner Ts. 3 and 4 N., Rs. 16 and 17 E., iron post	925.96
Corner Ts. 2 and 3 N., Rs. 16 and 17 E., iron post	704.692
Corner Ts. 2 and 3 N., Rs. 15 and 16 E., iron post	888.43
Corner Ts. 2 and 3 N., Rs. 14 and 15 E., iron post	1,068.734

	Feet.
Corner Ts. 2 and 3 N., Rs. 13 and 14 E., iron post	773. 199
Corner Ts. 2 and 3 N., Rs. 12 and 13 E., iron post	718. 35
Corner Ts. 1 and 2 N., Rs. 12 and 13 E., iron post	824. 747
Corner Ts. 1 and 2 N., Rs. 13 and 14 E., iron post	789. 85
Corner Ts. 1 and 2 N., Rs. 14 and 15 E., iron post	996.
Corner Ts. 1 and 2 N., Rs. 15 and 16 E., iron post	1, 025.
Corner Ts. 1 and 2 N., Rs. 16 and 17 E., iron post	703.
Standard corner T. 1 N., Rs. 16 and 17 E., iron post	1, 016. 855
Closing corner T. 1 S., Rs. 16 and 17 E., iron post	975. 854
Standard corner T. 1 N., Rs. 15 and 16 E., iron post	1, 081. 443
Closing corner T. 1 S., Rs. 15 and 16 E., iron post	1, 038. 518
Standard corner T. 1 N., Rs. 14 and 15 E., iron post	969. 031
Closing corner T. 1 S., Rs. 14 and 15 E., iron post	964. 431
Standard corner T. 1 N., Rs. 13 and 14 E., iron post	748. 611
Closing corner T. 1 S., Rs. 13 and 14 E., iron post	755. 499
Standard corner T. 1 N., Rs. 12 and 13 E., iron post	660. 205
Closing corner T. 1 S., Rs. 12 and 13 E., iron post	657. 105

COALGATE QUADRANGLE.

The railroad levels were run by Messrs. G. A. Purington, W. R. Manning, and E. L. Faison. Messrs. R. Coe, T. C. Catchings, F. E. Fellows, and W. S. D. Moore had independent level parties, while Mr. J. P. Walker was attached to the topographic and subdivision party of Mr. Jeremiah Ahern, and Mr. H. L. Muldrow, jr., to that of Mr. R. H. McKee.

FROM STUART, ALONG THE CHOCTAW, OKLAHOMA AND GULF RAILROAD, TO CALVIN.

	Feet.
Stuart, 3 miles east of; square hole cut in northwest corner of top stone on the south side of west pier of bridge No. 187	692. 225
Stuart, 1 mile east of; square hole cut in large stone 300 feet west of bridge No. 186, and 40 feet north of track near entrance to "cut"	708. 088
Stuart; iron post 60 feet north of track, 100 feet east of station, and south post-office	721. 885
Calvin, 2 miles east of; iron spike in mile pole No. 123	706. 711
Calvin; iron post south of track, in line of telegraph poles, 210 feet west of Calvin station ticket-office window	714. 693
Calvin, 4 miles west of; iron spike in mile pole No. 117	710. 564

ON THE MISSOURI, KANSAS AND TEXAS RAILWAY.

Chili; post oak 30 inches in diameter, 60 feet left of track and 450 feet south of mile pole No. 596	663. 655
Chili, 3 miles south of; elm 10 inches in diameter, 100 feet right of track, and 700 feet north of mile pole No. 599	617. 53

ON COALGATE BRANCH OF MISSOURI, KANSAS AND TEXAS RAILWAY.

Coalgate; iron post flush with ground at the southeast corner of station building, 50 feet east of track	614. 637
Coalgate; bronze tablet set into layer of foundation stone, 8 inches above the ground at the northwest corner of building owned by Cooperative Company, situated on Broadway street, about 400 feet southwest of railway station building	614. 714

ALONG TOWNSHIP LINES.

	Feet.
Corner Ts. 5 and 6 N., Rs. 8 and 9 E., iron post	896.761
Corner Ts. 5 and 6 N., Rs. 9 and 10 E., iron post	794.612
Corner Ts. 5 and 6 N., Rs. 10 and 11 E., iron post	818.931
Corner Ts. 5 and 6 N., Rs. 11 and 12 E., iron post	955.882
Standard corner T. 5 N., Rs. 11 and 12 E., iron post	784.122
Closing corner T. 4 N., Rs. 11 and 12 E., iron post	766.978
Standard corner T. 5 N., Rs. 10 and 11 E., iron post	888.106
Closing corner T. 4 N., Rs. 10 and 11 E., iron post	891.46
Standard corner T. 5 N., Rs. 9 and 10 E., iron post	823.922
Closing corner T. 4 N., Rs. 9 and 10 E., iron post	824.039
Standard corner T. 5 N., Rs. 8 and 9 E., iron post	892.731
Choctaw-Chickasaw boundary line, closing corner Ts. 4 and 5 N., R. 8 E., iron post	785.609
Choctaw-Chickasaw boundary line, closing corner Ts. 3 and 4 N., R. 8 E., iron post	760.77
Corner Ts. 3 and 4 N., Rs. 8 and 9 E., iron post	693.706
Corner Ts. 3 and 4 N., Rs. 9 and 10 E., iron post	710.782
Corner Ts. 3 and 4 N., Rs. 10 and 11 E., iron post	770.941
Corner Ts. 3 and 4 N., Rs. 11 and 12 E., iron post	699.131
Corner Ts. 2 and 3 N., Rs. 11 and 12 E., iron post	691.794
Corner Ts. 2 and 3 N., Rs. 10 and 11 E., iron post	663.661
Corner Ts. 2 and 3 N., Rs. 9 and 10 E., iron post	640.794
Corner Ts. 2 and 3 N., Rs. 8 and 9 E., iron post	697.741
Choctaw-Chickasaw boundary line, closing corner Ts. 2 and 3 N., R. 8 E., iron post	727.957
Choctaw-Chickasaw boundary line, closing corner Ts. 1 and 2 N., R. 8 E., iron post	628.752
Corner Ts. 1 and 2 N., Rs. 8 and 9 E., iron post	674.74
Corner Ts. 1 and 2 N., Rs. 9 and 10 E., iron post	664.744
Corner Ts. 1 and 2 N., Rs. 10 and 11 E., iron post	626.753
Corner Ts. 1 and 2 N., Rs. 11 and 12 E., iron post	640.758
Standard corner T. 1 N., Rs. 11 and 12 E., iron post	679.548
Standard corner T. 1 N., Rs. 10 and 11 E., iron post	563.579
Standard corner T. 1 N., Rs. 9 and 10 E., iron post	657.084
Standard corner T. 1 N., Rs. 8 and 9 E., iron post	649.255
Choctaw-Chickasaw boundary line, closing corner Ts. 1 N. and 1 S., R. 8 E., iron post	732.941

ALONG THE CHICKASAW-CHOCTAW BOUNDARY LINE.

Closing corner of Chickasaw Survey, on Chickasaw-Choctaw boundary, between Ts. 1 and 2 N., R. 8 E., iron post	629.258
Closing corner of Chickasaw Survey, on Chickasaw-Choctaw boundary, between Ts. 2 and 3 N., R. 8 E., iron post	728.503
Closing corner of Chickasaw Survey, on Chickasaw-Choctaw boundary, between Ts. 3 and 4 N., R. 8 E., iron post	760.547
Closing corner of Chickasaw Survey, on Chickasaw-Choctaw boundary, between Ts. 4 and 5 N., R. 8 E., iron post	777.995

STONEWALL QUADRANGLE (INDIAN TERRITORY-OKLAHOMA).

Messrs. W. R. Manning and W. S. D. Moore had charge of independent level parties. Mr. J. P. Walker was attached to the subdivision and topographic party of Mr. Jeremiah Ahern, while Mr. E. M. Fry was with Mr. R. A. Farmer's party, and Mr. H. L. Muldrow, jr., with Mr. R. H. McKee's party.

ALONG TOWNSHIP AND SECTION LINES.

	Feet.
Canadian River, meander corner on; between T. 5 N., R. 3 E., sec. 2, and T. 6 N., R. 3 E., sec. 35, iron post	916.65
Canadian River, meander corner on; between T. 6 N., R. 3 E., sec. 25, and T. 6 N., R. 4 E., sec. 30, iron post	905.28
Corner Ts. 5 and 6 N., Rs. 3 and 4 E., iron post	1,025.43
Canadian River, meander corner on; between T. 5 N., R. 4 E., sec. 5, and T. 6 N., R. 4 E., sec. 32, iron post	896.85
Canadian River, meander corner on; between T. 5 N., R. 4 E., sec. 1, and T. 5 N., R. 5 E., sec. 6, iron post	878.794
Seminole-Oklahoma boundary, closing corner on; between fractional Ts. 5 and 6 N., R. 5 E., iron post	1,054.695
Corner Ts. 5 and 6 N., Rs. 5 and 6 E., iron post	929.989
Corner Ts. 5 and 6 N., Rs. 6 and 7 E., iron post	889.552
Corner Ts. 5 and 6 N., Rs. 7 and 8 E., iron post	850.683
Standard corner T. 5 N., Rs. 7 and 8 E., iron post	918.331
Closing corner T. 4 N., Rs. 7 and 8 E., iron post	947.576
Standard corner T. 5 N., Rs. 6 and 7 E., iron post	955.867
Closing corner T. 4 N., Rs. 6 and 7 E., iron post	946.223
Standard corner T. 5 N., Rs. 5 and 6 E., iron post	896.745
Closing corner T. 4 N., Rs. 5 and 6 E., iron post	884.069
Standard corner T. 5 N., Rs. 4 and 5 E., iron post	999.868
Closing corner T. 4 N., Rs. 4 and 5 E., iron post	1,006.824
Standard corner T. 5 N., Rs. 3 and 4 E., iron post	1,094.94
Closing corner T. 4 N., Rs. 3 and 4 E., iron post	1,081.925
Corner Ts. 3 and 4 N., Rs. 3 and 4 E., iron post	1,083.302
Corner Ts. 3 and 4 N., Rs. 4 and 5 E., iron post	974.885
Corner Ts. 3 and 4 N., Rs. 5 and 6 E., iron post	932.219
Corner Ts. 3 and 4 N., Rs. 6 and 7 E., iron post	966.648
Corner Ts. 3 and 4 N., Rs. 7 and 8 E., iron post	843.572
Corner Ts. 2 and 3 N., Rs. 7 and 8 E., iron post	751.493
Corner Ts. 2 and 3 N., Rs. 6 and 7 E., iron post	750.477
Corner Ts. 2 and 3 N., Rs. 5 and 6 E., iron post	1,049.052
Corner Ts. 2 and 3 N., Rs. 4 and 5 E., iron post	1,169.605
Corner Ts. 2 and 3 N., Rs. 3 and 4 E., iron post	1,168.524
Corner Ts. 1 and 2 N., Rs. 3 and 4 E., iron post	1,078.938
Corner Ts. 1 and 2 N., Rs. 4 and 5 E., iron post	1,253.431
Corner Ts. 1 and 2 N., Rs. 5 and 6 E., iron post	1,139.508
Corner Ts. 1 and 2 N., Rs. 6 and 7 E., iron post	822.716
Corner Ts. 1 and 2 N., Rs. 7 and 8 E., iron post	745.122
Standard corner T. 1 N., Rs. 7 and 8 E., iron post	793.223
Standard corner T. 1 N., Rs. 6 and 7 E., iron post	1,061.658
Standard corner T. 1 N., Rs. 5 and 6 E., iron post	1,098.691
Standard corner T. 1 N., Rs. 4 and 5 E., iron post	1,159.841
Closing corner T. 1 S., Rs. 4 and 5 E., iron post	1,155.909
Standard corner T. 1 N., Rs. 3 and 4 E., iron post	1,198.234
Closing corner T. 1 S., Rs. 3 and 4 E., iron post	1,194.88

PAULS VALLEY QUADRANGLE (INDIAN TERRITORY-OKLAHOMA).

Messrs. R. Coe and A. F. Hassan ran the railroad levels. Mr. W. R. Manning had an independent level party. Messrs. W. S. D. Moore, G. Given, and E. M. Fry were attached to the subdivision and topographic party of Mr. R. A. Farmer, and Mr. J. H. Carlock to that of Mr. C. W. Goodlove.

PURCELL QUADRANGLE (INDIAN TERRITORY-OKLAHOMA).

Railroad levels were run by Mr. R. Coe. Messrs. W. S. D. Moore and E. M. Fry were attached to the subdivision and topographic party of Mr. R. A. Farmer.

ON THE GULF, COLORADO AND SANTA FE RAILWAY.

	Feet.
Purcell; bronze tablet set in middle of south face of second stone from southwest corner in the first course of stone above basement, in building used as U. S. court-house	1,091.691
Purcell, 4¾ miles north of; on the northeast rivet on bridge plate on east side of south pier of bridge over Canadian River	1,057.533

ALONG TOWNSHIP AND SECTION LINES.

Corner Ts. 7 and 8 N., Rs. 2 and 3 W., iron post	1,136.707
Canadian River, meander corner on, between T. 7 N., R. 2 W., sec. 4, and T. 8 N., R. 2 W., sec. 33; iron post	1,964.047
Canadian River, meander corner on, between T. 6 N., R. 2 W., sec. 1, and T. 7 N., R. 2 W., sec. 36; iron post	1,029.167
Corner Ts. 6 and 7 N., Rs. 2 and 3 W., iron post	1,124.077

SEMINOLE QUADRANGLE (INDIAN TERRITORY-OKLAHOMA).

The railroad levels were run by Mr. E. L. Faison. Messrs. W. S. D. Moore, W. R. Manning, and E. L. Faison had independent level parties.

FROM WEWOKA, INDIAN TERRITORY, ALONG CHOCTAW, OKLAHOMA AND GULF RAILROAD, TO SHAWNEE, OKLAHOMA.

	Feet.
Wewoka, 6 miles west of; iron spike in mile pole 93	833.464
Wewoka, 9 miles west of; iron post 5.7 feet west of mile pole 90	838.57
Earlsboro, Oklahoma Territory, 6 miles east of; iron spike in mile pole 85.	861.912
Earlsboro; iron post 17 feet west of main track and 200 feet north of station building	1,024.714
Tecumseh; spike in telegraph pole at junction of the Choctaw, Oklahoma and Gulf Railroad and Tecumseh Railroad	991.38
Shawnee; iron post 15 feet north of track and at east end of station platform	1,040.674
Shawnee, 4 miles west of, near Dale; iron post at mile pole 66	1,018.126

ALONG TOWNSHIP LINES.

Creek-Oklahoma boundary, closing corner Ts. 11 and 12 N., R. 6 E., iron post	979.38
Corner Ts. 11 and 12 N., Rs. 6 and 7 E., iron post	921.773
Corner Ts. 11 and 12 N., Rs. 7 and 8 E., iron post	937.515
Corner Ts. 10 and 11 N., Rs. 7 and 8 E., iron post	989.174
Corner Ts. 10 and 11 N., Rs. 6 and 7 E., iron post	901.875
Corner Ts. 10 and 11 N., Rs. 5 and 6 E., iron post	989.61
Seminole-Oklahoma boundary line, closing corner Ts. 10 and 11 N., R. 5 E., iron post	946.122
Seminole-Oklahoma boundary, closing corner Ts. 9 and 10 N., R. 5 E., iron post	993.871

FROM MINCO, SOUTH ALONG CHICAGO, ROCK ISLAND AND PACIFIC RAILWAY, TO CHICKASHA.

	Feet.
Minco, 1½ miles south of; iron post, 12 inches out of ground, at ¼ section corner between T. 9 N., R. 7 W., sec. 4, and T. 10 N., R. 7 W., sec. 33, and about 150 feet east of track	1,283.774
Minco, 7½ miles south of; iron post, 15 inches out of ground, at corner to secs. 32 and 33, of T. 9 N., R. 7 W., on the second standard parallel north, and about 600 feet west of track	1,201.295
Chickasha, 4½ miles north of; iron post, 12 inches out of ground, at ¼ section corner between T. 7 N., R. 7 W., sec. 4, and T. 8 N., R. 7 W., sec. 33, about 600 feet east of track	1,101.79
Chickasha; bronze tablet set in middle of east face of foundation stone at northeast corner of brick building owned by J. C. Griggers and situated at the corner of Chickasha avenue and Second street	1,090 967
Chickasha, 1¾ miles south of; iron post, 8 inches out of ground, at ¼ section corner between T. 6 N., R. 7 W., sec. 3, and T. 7 N., R. 7 W., sec. 34, about 180 feet west of track	1,084.071

ALONG TOWNSHIP AND SECTION LINES.

Chickasaw Nation, closing corner of Ts. 9 and 10 N., R. 7 W., on the west boundary of; iron post	1,287.534
Corner Ts. 9 and 10 N., Rs. 6 and 7 W., iron post	1,332.564
Corner Ts. 9 and 10 N., Rs. 5 and 6 W., iron post	1,306.784
Corner Ts. 9 and 10 N., Rs. 4 and 5 W., iron post	1,282.664
Canadian River, meander corner on, between T. 9 N., R. 4 W., sec. 1, and T. 10 N., R. 4 W., sec. 36; iron post	1,144.084
Canadian River, meander corner on, between T. 8 N., R. 3 W., sec. 5, and T. 9 N., R. 3 W., sec. 32; iron post	1,110.827
Closing corner T. 8 N., Rs. 3 and 4 W., iron post	1,177.227
Standard corner T. 9 N., Rs. 3 and 4 W., iron post	1,180.967
Closing corner T. 8 N., Rs. 4 and 5 W., iron post	1,283.967
Standard corner T. 9 N., Rs. 4 and 5 W., iron post	1,290.657
Closing corner T. 8 N., Rs. 5 and 6 W., iron post	1,288.605
Standard corner T. 9 N., Rs. 5 and 6 W., iron post	1,300.125
Closing corner T. 8 N., Rs. 6 and 7 W., iron post	1,222.395
Standard corner T. 9 N., Rs. 6 and 7 W., iron post	1,206.805
Chickasaw Nation, closing corner Ts. 8 and 9 N., R. 7 W., on the west boundary of; iron post	1,184.225
Chickasaw Nation, closing corner Ts. 7 and 8 N., R. 7 W., on the west boundary of; iron post	1,165.22
Corner Ts. 7 and 8 N., Rs. 6 and 7 W., iron post	1,218.47
Corner Ts. 7 and 8 N., Rs. 5 and 6 W., iron post	1,213.46
Corner Ts. 7 and 8 N., Rs. 4 and 5 W., iron post	1,260.247
Corner Ts. 7 and 8 N., Rs. 3 and 4 W., iron post	1,111.047
Corner Ts. 6 and 7 N., Rs. 3 and 4 W., iron post	1,219.167
Corner Ts. 6 and 7 N., Rs. 4 and 5 W., iron post	1,168.727
Corner Ts. 6 and 7 N., Rs. 5 and 6 W., iron post	1,152.061
Corner Ts. 6 and 7 N., Rs. 6 and 7 W., iron post	1,078,351
Chickasaw Nation, closing corner Ts. 6 and 7 N., R. 7 W., on the west boundary; iron post	1,155.551

PAWNEE QUADRANGLE (INDIAN TERRITORY-OKLAHOMA).

This bench mark was established by Mr. W. R. Manning on a double-rodded line.

	Feet.
Corner secs. 13 and 24, T. 18 N., R. 6 E., and secs. 18 and 19, T. 18 N., R. 7 E.; a sandstone post, 35 by 6 by 6 inches, with bronze tablet inserted	777.287

HOMINY QUADRANGLE (INDIAN TERRITORY-OKLAHOMA).

Mr. C. B. Odell ran the levels along the railroad, and he also had charge of an independent level party on township lines.

ALONG THE ST. LOUIS AND SAN FRANCISCO RAILROAD FROM RED FORK TO SAPULPA.

	Feet.
Red Fork, 3 miles south of; square hole cut in capstone of south pier of bridge over Nickle Creek	728.201
Sapulpa, bronze tablet set into wall of Gladstone Hotel, 14 feet from east end and 3.5 feet above porch	722.862
Sapulpa, copper bolt in sandstone post, 9 by 9 by 20 inches, buried flush with surface of ground, 11.5 feet from northwest corner of station	718.491

ALONG TOWNSHIP LINES.

Creek-Oklahoma boundary, closing corner of T. 19 N., Rs. 11 and 12 E., iron post	737.081
Corner Ts. 18 and 19 N., Rs. 11 and 12 E., iron post	746.531

ADDINGTON QUADRANGLE.

The railroad levels were run by Mr. R. Coe. Mr. Coe also had an independent party to run levels on the first standard parallel south. Messrs. J. P. Walker and H. L. Baker were attached to the subdivision and topographic party of Mr. A. D. Morton, while Messrs. R. T. Carnall and R. Coe were with Mr. J. Ahern's party and Mr. E. M. Fry with Mr. R. A. Farmer's party.

FROM COMANCHE, SOUTH ALONG THE CHICAGO, ROCK ISLAND AND PACIFIC RAILWAY, TO RYAN.

	Feet.
Comanche, 4 miles north of; a railroad spike in telegraph mile pole 481	1,024.795
Comanche, iron post 5 inches out of ground and on the south side of the station building; the post is set between the platform and a telegraph pole	979.723
Comanche, 2 miles south of; a railroad spike in telegraph mile pole 487	958.439
Addington, a square hole cut in the northwest corner of top stone of north foundation and in second tier from front of the water tank at	917.67
Addington, 4½ miles south of; square hole cut in coping stone on west end of south pier of bridge 3202 over Cow Creek, and about 1,100 feet north of mile pole 499	883.264
Sugden, ½ mile south of; an iron post at the standard corner of T. 5 S., Rs. 7 and 8 W., and about 1,600 feet west of the point of intersection of the railroad with the first standard parallel south	843.965
Ryan, 1 mile north of; on outside anchor bolt on west side of south pier *of bridge 3212 over* Beaver Creek	827.204

ALONG TOWNSHIP LINES.

	Feet.
Chickasaw Nation, closing corner fractional Ts. 1 and 2 S., R. 8 W., on west boundary, iron post	1,095.955
Corner Ts. 1 and 2 S., Rs. 7 and 8 W., iron post	1,123.275
Corner Ts. 1 and 2 S., Rs. 6 and 7 W., iron post	1,127.5
Corner Ts. 1 and 2 S., Rs. 5 and 6 W., iron post	1,081.88
Corner Ts. 1 and 2 S., Rs. 4 and 5 W., iron post	1,218.23
Corner Ts. 1 and 2 S., Rs. 3 and 4 W., iron post	1,084.679
Corner Ts. 2 and 3 S., Rs. 3 and 4 W., iron post	1,056.232
Corner Ts. 2 and 3 S., Rs. 4 and 5 W., iron post	967.009
Corner Ts. 2 and 3 S., Rs. 5 and 6 W., iron post	931.539
Corner Ts. 2 and 3 S., Rs. 6 and 7 W., iron post	987.769
Corner Ts. 2 and 3 S., Rs. 7 and 8 W., iron post	1,062.269
Chickasaw Nation, closing corner fractional Ts. 2 and 3 S., R. 8 W., on the west boundary of the, iron post	1,005.399
Chickasaw Nation, closing corner fractional Ts. 3 and 4 S., R. 8 W., on the west boundary of the, iron post	970.15
Corner Ts. 3 and 4 S., Rs. 7 and 8 W., iron post	908.29
Corner Ts. 3 and 4 S., Rs. 6 and 7 W., iron post	969.22
Corner Ts. 3 and 4 S., Rs. 5 and 6 W., iron post	856.87
Corner Ts. 3 and 4 S., Rs. 4 and 5 W., iron post	974.97
Corner Ts. 3 and 4 S., Rs. 3 and 4 W., iron post	1,038.289
Corner Ts. 4 and 5 S., Rs. 3 and 4 W., iron post	848.247
Corner Ts. 4 and 5 S., Rs. 4 and 5 W., iron post	820.107
Corner Ts. 4 and 5 S., Rs. 5 and 6 W., iron post	899.977
Corner Ts. 4 and 5 S., Rs. 6 and 7 W., iron post	894.199
Corner Ts. 4 and 5 S., Rs. 7 and 8 W., iron post	945.446
Standard corner T. 5 S., Rs. 6 and 7 W., iron post	913.225
Standard corner T. 5 S., Rs. 5 and 6 W., iron post	846.21
Standard corner T. 5 S., Rs. 4 and 5 W., iron post	797.39
Closing corner T. 6 S., Rs. 4 and 5 W., iron post	785.24
Standard corner T. 5 S., Rs. 3 and 4 W., iron post	847.62
Closing corner T. 6 S., Rs. 3 and 4 W., iron post	809.475
Chickasaw Nation, closing corner of fractional Ts. 4 and 5 S., R. 8 W., on the west boundary of, iron post	871.686
Chickasaw Nation, closing corner of the First Standard Parallel South, on the west boundary of the, and is in R. 8 W. of the Chickasaw Survey, iron post	904.44

ARDMORE QUADRANGLE.

The railroad levels were run by Mr. A. F. Hassan and Mr. R. Coe. Messrs. J. H. Carlock and H. L. Baker were attached to the subdivision and topographic party of Mr. C. W. Goodlove, while Mr. E. M. Fry was with Mr. R. A. Farmer's party and Mr. R. T. Carnall with Mr. J. Ahern's party. Mr. R. Coe had charge of an independent level party.

FROM OVERBROOK, NORTH ALONG GULF, COLORADO AND SANTA FE RAILWAY, TO DOUGHERTY.

	Feet.
Overbrook, 4½ miles south of; cross mark cut 8 inches from west edge of west coping of north pier of bridge 338, over Little Hickory Creek	967.878
Overbrook, ½ mile northwest of; iron post at standard corner T. 5 S., Rs. *1 and 2 E., and 1,300 feet west of railway*	786.055

	Fa
Overbrook, railroad spike in telegraph mile pole 443, near station	735.
Ardmore, 1 mile south of; iron post at intersection of railway with township line, between Ts. 4 and 5 S., R. 2 E., near mile pole 449, and 30 feet west of center of track	861
Ardmore; bronze tablet in sandstone foundation of Noble Bros.' hardware store at southeast angle of railway crossing on Main street	872
Ardmore, 6 miles north of; iron post at intersection of railway with township line between Ts. 3 and 4 S., R. 2 E., in line with telegraph poles and 50 feet south of second pole west of track	708
Berwyn, 3 miles north of; copper bolt set in east side of coping stone of north pier of bridge No. 402, over Cool Creek, and near mile pole 464	752
Dougherty, 3,000 feet south of; railroad spike in mile pole 469	765
Dougherty, 2 miles north of; iron post at intersection of railway with township line between Ts. 1 and 2 S., R. 2 E., 30 feet left of track and 6 feet south of telegraph pole, 300 feet south of bridge 417, which is 3,000 feet south of mile pole 472	761

ALONG TOWNSHIP LINES.

Corner Ts. 1 and 2 S., Rs. 2 and 3 W., iron post	1,047
Corner Ts. 1 and 2 S., Rs. 1 and 2 W., iron post	1,171
Corner Ts. 1 and 2 S., Rs. 1 E. and 1 W., iron post	1,304
Corner Ts. 1 and 2 S., Rs. 1 and 2 E., iron post	1,090
Corner Ts. 1 and 2 S., Rs. 2 and 3 E., iron post	786
Corner Ts. 2 and 3 S., Rs. 2 and 3 E., iron post	808
Corner Ts. 2 and 3 S., Rs. 1 and 2 E., iron post	906
Corner Ts. 2 and 3 S., Rs. 1 E. and 1 W., iron post	912
Corner Ts. 2 and 3 S., Rs. 1 and 2 W., iron post	884
Corner Ts. 2 and 3 S., Rs. 2 and 3 W., iron post	1,034
Corner Ts. 3 and 4 S., Rs. 2 and 3 W., iron post	878
Corner Ts. 3 and 4 S., Rs. 1 and 2 W., iron post	927
Corner Ts. 3 and 4 S., Rs. 1 E. and 1 W., iron post	868
Corner Ts. 3 and 4 S., Rs. 1 and 2 E., iron post	748
Witness corner Ts. 3 and 4 S., Rs. 2 and 3 E., iron post	718
Corner Ts. 4 and 5 S., Rs. 2 and 3 E., iron post	890
Corner Ts. 4 and 5 S., Rs. 1 and 2 E., iron post	858
Corner Ts. 4 and 5 S., Rs. 1 E. and 1 W., iron post	950
Corner Ts. 4 and 5 S., Rs. 1 and 2 W., iron post	857
Corner Ts. 4 and 5 S., Rs. 2 and 3 W., iron post	991
Standard corner T. 5 S., Rs. 2 and 3 W., iron post	927
Closing corner T. 6 S., Rs. 2 and 3 W., iron post	930
Standard corner T. 5 S., Rs. 1 and 2 W., iron post	888
Closing corner T. 6 S., Rs. 1 and 2 W., iron post	902
Indian meridian, intersection of first standard parallel south with; iron post, Ts. 5 and 6 S., Rs. 1 E. and 1 W	818
Standard corner T. 5 S., Rs. 2 and 3 E., iron post	817

TISHOMINGO QUADRANGLE.

Mr. W. R. Manning had charge of an independent level party. H. L. Muldrow, jr., was attached to the subdivision and topogra party of Mr. R. H. McKee, and Mr. J. H. Carlock to that of Mr W. Goodlove.

ALONG TOWNSHIP LINES.

	Feet.
Corner Ts. 1 and 2 S., Rs. 3 and 4 E., iron post	1,052.289
Corner Ts. 1 and 2 S., Rs. 4 and 5 E., iron post	1,035.779
Corner Ts. 1 and 2 S., Rs. 5 and 6 E., iron post	1,036.039
Corner Ts. 1 and 2 S., Rs. 6 and 7 E., iron post	967.079
Corner Ts. 1 and 2 S., Rs. 7 and 8 E., iron post	738.843
Corner Ts. 2 and 3 S., Rs. 7 and 8 E., iron post	782.572
Corner Ts. 2 and 3 S., Rs. 6 and 7 E., iron post	845.012
Corner Ts. 2 and 3 S., Rs. 5 and 6 E., iron post	891.322
Corner Ts. 2 and 3 S., Rs. 4 and 5 E.; bronze tablet set into township corner stone, which stone is a stone in place	903.212
Corner Ts. 2 and 3 S., Rs. 3 and 4 E., iron post	858.382
Corner Ts. 3 and 4 S., Rs. 3 and 4 E., iron post	779.049
Corner Ts. 3 and 4 S., Rs. 4 and 5 E., iron post	809.549
Corner Ts. 3 and 4 S., Rs. 5 and 6 E., iron post	694.599
Corner Ts. 3 and 4 S., Rs. 6 and 7 E., iron post	718.139
Corner Ts. 3 and 4 S., Rs. 7 and 8 E., iron post	726.319
Corner Ts. 4 and 5 S., Rs. 7 and 8 E., iron post	736.445
Corner Ts. 4 and 5 S., Rs. 6 and 7 E., iron post	598.755
Corner Ts. 4 and 5 S., Rs. 5 and 6 E., iron post	785.525
Corner Ts. 4 and 5 S., Rs. 4 and 5 E., iron post	793.075
Corner Ts. 4 and 5 S., Rs. 3 and 4 E., iron post	858.075
Standard corner T. 5 S., Rs. 3 and 4 E., iron post	730.03
Closing corner T. 6 S., Rs. 4 and 5 E., iron post	871.866
Standard corner T. 5 S., Rs. 4 and 5 E., iron post	860.106
Standard corner T. 5 S., Rs. 5 and 6 E., iron post	687.477
Standard corner T. 5 S., Rs. 6 and 7 E., iron post	754.815
Standard corner T. 5 S., Rs. 7 and 8 E., iron post	657.441

ATOKA QUADRANGLE.

The railroad levels were run by Messrs. G. A. Purington and W. R. Manning. Messrs. R. Coe and W. R. Manning were in charge of independent level parties. Mr. H. L. Muldrow, jr., was attached to the subdivision and topographic party of Mr. R. H. McKee.

FROM STRINGTOWN, ALONG THE MISSOURI, KANSAS AND TEXAS RAILWAY, TO ARMSTRONG.

	Feet.
Stringtown, ½ mile south of; elm, 10 inches in diameter, 100 feet left of track and 1,000 feet south of mile pole 603	594.604
Atoka, ¼ mile north of; copper bolt sunk into second coping stone from east side of north pier of bridge 367, over Muddy Boggy Creek	540.375
Peck; nail in black-jack oak, 14 inches diameter, 40 feet left of track and 350 feet south of mile pole 615	616.096
Caney, ½ mile north of; copper bolt sunk into first step of west side of south abutment of bridge 388, 500 feet south of mile pole 621	517.217
Caddo, 2 miles north of; copper bolt sunk into second coping stone from east side of south abutment of bridge 403, 1,800 feet north of mile pole 627	591.561
Armstrong; copper bolt sunk into first coping stone from north edge of north abutment of bridge 421, over Blue River, 600 feet north of the Armstrong switch	567.491

ON COALGATE BRANCH OF THE MISSOURI, KANSAS AND TEXAS RAILWAY.

	F
Midway; spike in mile pole 5	59
Lehigh; bronze tablet set into stone of first layer of foundation near northeast corner of building owned by Joe. Grillery, and situated at the southwest corner of Main street and "Wild-Cat Row."	59

ALONG TOWNSHIP LINES.

Chickasaw-Choctaw boundary line, closing corner of Ts. 1 and 2 S., R. 8 E., of the Chickasaw survey on the, iron post	66
Chickasaw-Choctaw boundary line, closing corner of Ts. 1 and 2 S., R. 8 E., of the Choctaw survey on the, iron post	66
Corner Ts. 1 and 2 S., Rs. 8 and 9 E., iron post	61
Corner Ts. 1 and 2 S., Rs. 9 and 10 E., iron post	59
Corner Ts. 1 and 2 S., Rs. 10 and 11 E., iron post	59
Corner Ts. 1 and 2 S., Rs. 11 and 12 E., iron post	59
Corner Ts. 2 and 3 S., Rs. 11 and 12 E., iron post	59
Corner Ts. 2 and 3 S., Rs. 10 and 11 E., iron post	63
Corner Ts. 2 and 3 S., Rs. 9 and 10 E., iron post	53
Corner Ts. 2 and 3 S., Rs. 8 and 9 E., iron post	63
Chickasaw-Choctaw boundary line, closing corner of Ts. 2 and 3 S., R. 8 E., of the Choctaw Survey on the, iron post	70
Chickasaw-Choctaw boundary line, closing corner of Ts. 2 and 3 S., R. 8 E., of the Chickasaw Survey on the, iron post	76
Chickasaw-Choctaw boundary line, closing corner of Ts. 3 and 4 S., R. 8 E., of the Chickasaw Survey on the, iron post	65
Chickasaw-Choctaw boundary line, closing corner of Ts. 3 and 4 S., R. 8 E., of the Choctaw Survey on the, iron post	65
Corner Ts. 3 and 4 S., Rs. 8 and 9 E., iron post	71
Corner Ts. 3 and 4 S., Rs. 9 and 10 E., iron post	68
Corner Ts. 3 and 4 S., Rs. 10 and 11 E., iron post	50
Corner Ts. 3 and 4 S., Rs. 11 and 12 E., iron post	55
Standard corner T. 4 S., Rs. 11 and 12 E., iron post	52
Closing corner T. 5 S., Rs. 11 and 12 E., iron post	50
Standard corner T. 4 S., Rs. 10 and 11 E., iron post	64
Closing corner T. 5 S., Rs. 10 and 11 E., iron post	64
Standard corner T. 4 S., Rs. 9 and 10 E., iron post	63
Closing corner T. 5 S., Rs. 9 and 10 E., iron post	63
Standard corner Ts. 4 and 5 S., Rs. 8 and 9 E., intersection of 1st standard parallel south with the 2d guide meridian east; iron post	60
Chickasaw-Choctaw boundary line, closing corner Ts. 4 and 5 S., R. 8 E., of the Choctaw Survey on the, iron post	66
Chickasaw-Choctaw boundary line, closing corner Ts. 4 and 5 S., R. 8 E., of the Chickasaw Survey on the, iron post	66
Chickasaw-Choctaw boundary line, closing corner Ts. 5 and 6 S., R. 8 E., of the Chickasaw and Choctaw Surveys on the, iron post	70
Corner Ts. 5 and 6 S., Rs. 8 and 9 E., iron post	63
Corner Ts. 5 and 6 S., Rs. 9 and 10 E., iron post	63
Corner Ts. 5 and 6 S., Rs. 10 and 11 E., iron post	60
Corner Ts. 5 and 6 S., Rs. 11 and 12 E., iron post	71

ANTLERS QUADRANGLE.

Mr. H. C. McCluer ran the railroad levels. Messrs. Robert Coe, R. T. Carnall, and F. E. Fellows had independent level parties, while Mr. W. P. Halliday was attached to the topographic and subdivision party of Mr. W. S. Post.

ALONG THE ST. LOUIS AND SAN FRANCISCO RAILROAD FROM BUTLER TO GOODLAND.

	Feet.
Butler; elm, 14 inches diameter, 140 feet left of track and 400 feet south of mile pole 522	528.466
Wadena, ⅓ mile north of; square hole cut into west end of south abutment of bridge	491.285
Wadena; elm, 10 inches diameter, 90 feet left of track and 200 feet south of milepost 527	485.725
Kosoma, ⅓ mile south of; post oak, 12 inches diameter, 60 feet right of track and 1,700 feet south of mile pole 531	483.196
Rodney; post oak, 10 inches diameter, 90 feet left and 600 feet south of mile pole 537	468.436
Davenport, ⅓ mile south of; red oak, 15 inches in diameter, 100 feet left of track and opposite mile pole 539	474.286
Antlers; square hole cut into section corner stone, common to secs. 3, 4, 9, and 10, T. 4 S., R. 16 E.; 28 feet north of the northwest corner of the Antlers court-house building	508.856
Antlers, 4 miles south of; black-jack, 8 inches diameter, 100 feet right of track and 175 feet south of mile pole 546	558.753
Hamden; red oak, 24 inches diameter, 60 feet right of track and 50 feet east of mile pole 549	464.561
Goodland, 2 miles north of; red oak, 20 inches diameter, 60 feet right of track and 275 feet south of mile pole 554	494.116
Goodland, 1,000 feet north of station; elm tree, 6 inches in diameter, 60 feet right of track and 120 feet north of mile pole 556	491.969

ALONG TOWNSHIP LINES.

Corner Ts. 1 and 2 S., Rs. 12 and 13 E., iron post	724.63
Corner Ts. 1 and 2 S., Rs. 13 and 14 E., iron post	842.345
Corner Ts. 1 and 2 S., Rs. 14 and 15 E., iron post	943.7
Corner Ts. 1 and 2 S., Rs. 15 and 16 E., bronze tablet set into township corner stone, which is a "stone in place"	697.505
Corner Ts. 1 and 2 S., Rs. 16 and 17 E., iron post	665.505
Corner Ts. 2 and 3 S., Rs. 16 and 17 E., iron post	618.038
Corner Ts. 2 and 3 S., Rs. 15 and 16 E., iron post	812.5
Corner Ts. 2 and 3 S., Rs. 14 and 15 E., iron post	663.111
Corner Ts. 2 and 3 S., Rs. 13 and 14 E., iron post	580.896
Corner Ts. 2 and 3 S., Rs. 12 and 13 E., iron post	605.221
Corner Ts. 3 and 4 S., Rs. 12 and 13 E., iron post	568.509
Corner Ts. 3 and 4 S., Rs. 13 and 14 E., iron post	497.184
Corner Ts. 3 and 4 S., Rs. 14 and 15 E., iron post	622.234
Corner Ts. 3 and 4 S., Rs. 15 and 16 E., iron post	565.504
Corner Ts. 3 and 4 S., Rs. 16 and 17 E., iron post	453.518
Standard corner T. 4 S., Rs. 16 and 17 E., iron post	468.94

	Feet.
Closing corner T. 5 S., Rs. 16 and 17 E., iron post	503.77
Standard corner T. 4 S., Rs. 15 and 16 E., iron post	629.9
Closing corner T. 5 S., Rs. 15 and 16 E., iron post	620.755
Standard corner T. 4 S., Rs. 14 and 15 E., iron post	574.565
Closing corner T. 5 S., Rs. 14 and 15 E., iron post	531.42
Standard corner T. 4 S., Rs. 13 and 14 E., iron post	544.27
Closing corner T. 5 S., Rs. 13 and 14 E., iron post	531.81
Standard corner T. 4 S., Rs. 12 and 13 E., iron post	465.49
Closing corner T. 5 S., Rs. 12 and 13 E., iron post	465.755
Corner Ts. 5 and 6 S., Rs. 12 and 13 E., iron post	729.39
Corner Ts. 5 and 6 S., Rs. 13 and 14 E., iron post	523.99
Corner Ts. 5 and 6 S., Rs. 14 and 15 E., iron post	481.75
Corner Ts. 5 and 6 S., Rs. 15 and 16 E., iron post	516.25
Corner Ts. 5 and 6 S., Rs. 16 and 17 E., iron post	532.27

ALIKCHI QUADRANGLE.

Messrs. F. E. Fellows and V. T. Rhyne had charge of independent level parties. Messrs. F. E. Fellows and W. P. Halliday were attached for a time to the topographic and subdivision party of Mr. Oscar Jones, after which time Messrs. W. P. Halliday, Oscar Jones, and G. H. Bartlett were attached to the party under charge of Mr. W. S. Post.

ALONG TOWNSHIP LINES.

	Feet.
Corner Ts. 1 and 2 S., Rs. 17 and 18 E., iron post	567.905
Corner Ts. 1 and 2 S., Rs. 18 and 19 E., iron post	1,039.672
Corner Ts. 1 and 2 S., Rs. 19 and 20 E., iron post	813.882
Corner Ts. 1 and 2 S., Rs. 20 and 21 E., iron post	746.935
Corner Ts. 1 and 2 S., Rs. 21 and 22 E., iron post	947.3
Corner Ts. 2 and 3 S., Rs. 21 and 22 E., iron post	1,253.769
Corner Ts. 2 and 3 S., Rs. 20 and 21 E., iron post	592.811
Corner Ts. 2 and 3 S., Rs. 19 and 20 E., iron post	701.59
Corner Ts. 2 and 3 S., Rs. 18 and 19 E., iron post	973.502
Corner Ts. 2 and 3 S., Rs. 17 and 18 E., iron post	504.559
Corner Ts. 3 and 4 S., Rs. 17 and 18 E., iron post	692.986
Corner Ts. 3 and 4 S., Rs. 18 and 19 E., iron post	609.242
Corner Ts. 3 and 4 S., Rs. 19 and 20 E., iron post	845.637
Corner Ts. 3 and 4 S., Rs. 20 and 21 E., iron post	529.173
Corner Ts. 3 and 4 S., Rs. 21 and 22 E., iron post	700.452
Standard corner T. 4 S., Rs. 21 and 22 E., iron post	560.001
Closing corner T. 5 S., Rs. 21 and 22 E., iron post	527.005
Standard corner T. 4 S., Rs. 20 and 21 E., iron post	533.719
Closing corner T. 5 S., Rs. 20 and 21 E., iron post	546.338
Standard corner T. 4 S., Rs. 19 and 20 E., iron post	693.813
Closing corner T. 5 S., Rs. 19 and 20 E., iron post	681.673
Standard corner T. 4 S., Rs. 18 and 19 E., iron post	459.434
Closing corner T. 5 S., Rs. 18 and 19 E., iron post	466.257
Standard corner T. 4 S., Rs. 17 and 18 E., iron post	412.346
Closing corner T. 5 S., Rs. 17 and 18 E., iron post	414.285
Corner Ts. 5 and 6 S., Rs. 17 and 18 E., iron post	411.973
Corner Ts. 5 and 6 S., Rs. 18 and 19 E., iron post	434.619
Corner Ts. 5 and 6 S., Rs. 19 and 20 E., iron post	433.384
Corner Ts. 5 and 6 S., Rs. 20 and 21 E., iron post	606.513
Corner Ts. 5 and 6 S., Rs. 21 and 22 E., iron post	390.505

EAGLETOWN QUADRANGLE.

Mr. F. E. Fellows had charge of an independent level party. Messrs. W. P. Halliday, Oscar Jones, and G. H. Bartlett were attached to the topographic and subdivision party of Mr. W. S. Post.

ALONG TOWNSHIP LINES.

	Feet.
Corner Ts. 1 and 2 S., Rs. 22 and 23 E., iron post	779.16
Corner Ts. 1 and 2 S., Rs. 23 and 24 E., iron post	1,090.1
Corner Ts. 1 and 2 S., Rs. 24 and 25 E., iron post	960.52
Corner Ts. 1 and 2 S., Rs. 25 and 26 E., iron post	758.12
Corner Ts. 1 and 2 S., Rs. 26 and 27 E., iron post	1,020.309
Corner Ts. 2 and 3 S., Rs. 26 and 27 E., iron post	1,171.796
Corner Ts. 2 and 3 S., Rs. 25 and 26 E., iron post	1,045.613
Corner Ts. 2 and 3 S., Rs. 24 and 25 E., iron post	889.602
Corner Ts. 2 and 3 S., Rs. 23 and 24 E., iron post	944.902
Corner Ts. 2 and 3 S., Rs. 22 and 23 E., iron post	739.749
Corner Ts. 3 and 4 S., Rs. 22 and 23 E., iron post	743.173
Corner Ts. 3 and 4 S., Rs. 23 and 24 E., iron post	818.562
Corner Ts. 3 and 4 S., Rs. 24 and 25 E., iron post	685.697
Corner Ts. 3 and 4 S., Rs. 25 and 26 E., iron post	629.396
Corner Ts. 3 and 4 S., Rs. 26 and 27 E., iron post	1,086.588
Standard corner T. 4 S., Rs. 26 and 27 E., iron post	806.891
Closing corner T. 5 S., Rs. 26 and 27 E., iron post	827.648
Standard corner T. 4 S., Rs. 25 and 26 E., iron post	644.931
Closing corner T. 5 S., Rs. 25 and 26 E., iron post	590.208
Standard corner T. 4 S., Rs. 24 and 25 E., iron post	757.441
Closing corner T. 5 S., Rs. 24 and 25 E., iron post	681.951
Standard corner T. 4 S., Rs. 23 and 24 E., iron post	751.146
Closing corner T. 5 S., Rs. 23 and 24 E., iron post	738.316
Standard corner T. 4 S., Rs. 22 and 23 E., iron post	641.631
Closing corner T. 5 S., Rs. 22 and 23 E., iron post	749.346
Corner Ts. 5 and 6 S., Rs. 22 and 23 E., iron post	459.675
Corner Ts. 5 and 6 S., Rs. 23 and 24 E., iron post	492.322
Corner Ts. 5 and 6 S., Rs. 24 and 25 E., iron post	469.285
Corner Ts. 5 and 6 S., Rs. 25 and 26 E., iron post	449.933
Corner Ts. 5 and 6 S., Rs. 26 and 27 E., iron post	485.451

The following bench mark is situated just east of the Eagletown quadrangle:

	Feet.
Arkansas-Choctaw boundary line closing corner, first standard parallel south, between Ts. 4 and 5 S., R. 27 E., on the cross on stone corner	733.421

SHAWNEETOWN QUADRANGLE (INDIAN TERRITORY-TEXAS).

Levels were run by G. H. Bartlett, W. P. Halliday, F. E. Fellows, and O. Jones, who were attached to the subdivision and topographic party of Mr. W. S. Post, who was relieved by Mr. W. T. Turner.

ALONG TOWNSHIP AND SECTION LINES.

	Feet.
Corner Ts. 6 and 7 S., Rs. 22 and 23 E., iron post	401.319
Corner Ts. 6 and 7 S., Rs. 23 and 24 E., iron post	396.409
Corner Ts. 6 and 7 S., Rs. 24 and 25 E., iron post	358.914
Corner Ts. 6 and 7 S., Rs. 25 and 26 E., iron post	388.382

Corner Ts. 6 and 7 S., Rs. 26 and 27 E., iron post 3
Corner Ts. 7 and 8 S., Rs. 26 and 27 E., iron post 3
Corner Ts. 7 and 8 S., Rs. 25 and 26 E., iron post 3
Corner Ts. 7 and 8 S., Rs. 24 and 25 E., iron post 4
Corner Ts. 7 and 8 S., Rs. 23 and 24 E., iron post 5
Corner Ts. 7 and 8 S., Rs. 22 and 23 E., iron post 4
Red River, meander corner T. 8 S., Rs. 22 and 23 E., secs. 19 and 24, left bank of; mulberry 12 inches in diameter, which is northeast, bearing tree to meander corner 3
Closing corner T. 9 S., Rs. 23 and 24 E., iron post 3
Standard corner T. 8 S., Rs. 23 and 24 E., iron post 3
Closing corner T. 9 S., Rs. 24 and 25 E., iron post 4
Standard corner T. 8 S., Rs. 24 and 25 E., iron post 3
Closing corner T. 9 S., Rs. 25 and 26 E., iron post 4
Standard corner T. 8 S., Rs. 25 and 26 E., iron post 4
Closing corner T. 9 S., Rs. 26 and 27 E., iron post 4
Standard corner T. 8 S., Rs. 26 and 27 E., iron post 4
Corner Ts. 9 and 10 S., Rs. 26 and 27 E., iron post 3
Corner Ts. 9 and 10 S., Rs. 25 and 26 E., iron post 3
Witness corner Ts. 9 and 10 S., Rs. 24 and 25 E., iron post 3
Red River, Harris Ferry; 850 feet south of, witness corner to Ts. 9 and 10 S., Rs. 24 and 25 E., on root of bois d'arc tree 16 inches in diameter, left bank of 3
Red River, meander corner, T. 9 S., Rs. 23 and 24 E., secs. 25 and 30, left bank of; iron post 3

The following bench marks are just east of the Shawneetown rangle:

Arkansas-Choctaw boundary, closing corner, Ts. 7 and 8 S., R. 27 E., on the; iron post 4
Arkansas-Choctaw boundary, closing corner, second standard parallel south, between Ts. 8 and 9 S., R. 27 E., on the, nail in root of bearing tree 3

CLARKSVILLE QUADRANGLE (INDIAN TERRITORY-TEXAS

Mr. H. C. McCluer ran the railroad levels. Mr. J. H. Carloc an independent level party. Messrs. W. P. Halliday and O. were attached to the subdivision and topographic party of Mr. Post.

ON THE ST. LOUIS AND SAN FRANCISCO RAILROAD.

Arthur, Texas, ½ mile north of; copper bolt set into east coping stone of north abutment of bridge 440 4

ALONG TOWNSHIP AND SECTION LINES.

Corner Ts. 6 and 7 S., Rs. 17 and 18 E., iron post 5
Corner Ts. 6 and 7 S., Rs. 18 and 19 E., iron post 3
Corner Ts. 6 and 7 S., Rs. 19 and 20 E., iron post 3
Corner Ts. 6 and 7 S., Rs. 20 and 21 E., iron post 4
Corner Ts. 6 and 7 S., Rs. 21 and 22 E., iron post 4

	Feet.
Red River, meander corner between sec. 13, T. 7 S., R. 20 E., and sec. 18, T. 7 S., R. 21 E.; iron post on left bank of	375.954
Red River, meander corner between sec. 35, T. 7 S., R. 19 E., and sec. 2, T. 8 S., R. 19 E.; iron post on left bank of	394.841
Corner Ts. 7 and 8 S., Rs. 18 and 19 E., iron post	483.711
Corner Ts. 7 and 8 S., Rs. 17 and 18 E., iron post	414.561

PARIS QUADRANGLE (INDIAN TERRITORY-TEXAS).

The railroad levels were run by Mr. H. C. McCluer. Mr. J. H. Carlock had an independent level party.

FROM GRANT, INDIAN TERRITORY, ALONG THE ST. LOUIS AND SAN FRANCISCO RAILROAD, TO PARIS, TEXAS.

	Feet.
Grant, ¼ mile south of; red oak 8 inches in diameter, 50 feet right of track, 35 feet south of mile pole 564	463.98
Lenoir; post oak 8 inches in diameter, 40 feet left of track and 350 feet south of mile pole 573	526.319
Paris; spike in telegraph pole, 90 feet east of St. Louis and San Francisco Railroad, and 20 feet south of Texas and Pacific Railway	542.762

FROM BROOKSTON, TEXAS, ALONG THE TEXAS AND PACIFIC RAILWAY, TO HONEY GROVE, TEXAS.

Brookston; spike in mile pole 100	588.023
Petty, ½ mile west of; spike in mile pole 107	636.57
Honey Grove; copper bolt set into bottom step of the approach to First National Bank, corner of Fifth and Market streets	675.221

ALONG TOWNSHIP AND SECTION LINES.

Corner Ts. 6 and 7 S., Rs. 12 and 13 E., iron post	594.912
Corner Ts. 6 and 7 S., Rs. 13 and 14 E., iron post	602.772
Corner Ts. 6 and 7 S., Rs. 14 and 15 E., iron post	534.482
Corner Ts. 6 and 7 S., Rs. 15 and 16 E., iron post	484.372
Corner Ts. 6 and 7 S., Rs. 16 and 17 E., iron post	501.202
Red River, meander corner between sec. 32, T. 7 S., and sec. 5, T. 8 S., R. 17 E.; iron post on left bank of	412.291

BONHAM QUADRANGLE (INDIAN TERRITORY-TEXAS).

Messrs. W. R. Manning and H. C. McCluer ran the railroad levels. Messrs. J. H. Carlock and W. R. Manning had charge of independent level parties. Messrs. H. L. Baker and J. H. Carlock were attached to the subdivision and topographic party of Mr. C. W. Goodlove.

FROM DURANT, ALONG MISSOURI, KANSAS AND TEXAS RAILWAY, TO COLBERT.

	Feet.
Durant, ⅔ mile south of; copper bolt set in second coping stone from the west, 1.7 feet from the north edge and 3.3 feet from the west edge of first coping stone of the north abutment of bridge 430, over the Mineral Bayou	619.292

	Feet.
Cale, about 2,000 feet north of station; railroad spike in telegraph mile pole 646	694.573
Colbert, about 1,000 feet north of station; railroad spike in telegraph mile pole 653	661.696

FROM WINDOM, TEXAS, ALONG TEXAS AND PACIFIC RAILWAY, TO BELLS, TEXAS.

Windom; railroad spike in mile pole 117	691.938
Dodd City, about 3,000 feet east of station; railroad spike in bois d'arc tree, 10 inches in diameter, 75 feet right of track and 540 feet west of mile pole 121	645.772
Bonham, 1 mile east of; railroad spike in telegraph pole 180 feet west of mile pole 126	545.606
Ector, 2,500 feet east of station; railroad spike in mile pole 133	661.514
Savoy, 700 feet east of; spike in mile pole 139	673.137
Bells; railroad spike in mile pole 142	677.219

ALONG TOWNSHIP LINES.

Chickasaw-Choctaw boundary line, closing corner Ts. 6 and 7 S., R. 8 E., of the Choctaw survey on the, iron post	717.756
Corner Ts. 6 and 7 S., Rs. 8 and 9 E., iron post	668.435
Corner Ts. 6 and 7 S., Rs. 9 and 10 E., iron post	625.552
Corner Ts. 6 and 7 S., Rs. 10 and 11 E., iron post	565.822
Corner Ts. 6 and 7 S., Rs. 11 and 12 E., iron post	584.062
Chickasaw-Choctaw boundary line, closing corner Ts. 7 and 8 S., R. 8 E., of Chickasaw survey, on the, which is Island Bayou at this point; iron post	619.337
Corner Ts. 8 and 9 S., Rs. 8 and 9 E., iron post	624.766
Corner Ts. 8 and 9 S., Rs. 9 and 10 E., iron post	641.586
Corner Ts. 8 and 9 S., Rs. 10 and 11 E., iron post	494.096

DENISON QUADRANGLE (INDIAN TERRITORY-TEXAS).

The railroad levels were run by Messrs. W. R. Manning, H. C. McCluer, R. T. Carnall, and A. F. Hassan. Mr. J. H. Carlock was attached to the subdivision and topography party of Mr. C. W. Goodlove, which did the Indian Territory portion of the quadrangle, and Mr. A. F. Hassan ran primary and secondary levels for Mr. J. Ahern's topographic party, which worked the Texas portion.

ALONG TOWNSHIP AND SECTION LINES.

	Feet.
Corner Ts. 6 and 7 S., Rs. 3 and 4 E., iron post	662.168
Corner Ts. 6 and 7 S., Rs. 4 and 5 E., iron post	761.047
Corner Ts. 6 and 7 S., Rs. 5 and 6 E., iron post	749.797
Corner Ts. 6 and 7 S., Rs. 6 and 7 E., iron post	583.907
Corner Ts. 6 and 7 S., Rs. 7 and 8 E., iron post	684.317
Corner Ts. 7 and 8 S., Rs. 7 and 8 E., iron post	668.517
Red River, meander corner on, T. 7 S., R. 7 E., sec. 33, and T. 8 S., R. 7 E., sec. 4; on stone	542.117
Red River, meander corner on, between T. 7 S., R. 6 E., sec. 33, and T. 8 S., R. 6 E., sec. 4; on stone	549.631

	Feet.
Corner Ts. 7 and 8 S., Rs. 5 and 6 E., iron post	725.621
Corner Ts. 7 and 8 S., Rs. 4 and 5 E., iron post	721.271
Red River, meander corner on, between T. 7 S., R. 4 E., sec. 33, and T. 8 S., R. 4 E., sec. 4; on stone	568.861
Red River, meander corner on, between T. 7 S., R. 4 E., sec. 7, and T. 7 S., R. 3 E., sec. 12; iron post	592.958
Red River, meander corner on, between T. 7 S., R. 3 E., sec. 34, and T. 8 S., R. 3 E., sec. 3; on stone	604.726
Red River, meander corner on, between T. 8 S., R. 4 E., sec. 12, and T. 8 S., R. 4 E., sec. 7; iron post	576.62
Red River, meander corner on, between T. 8 S., R. 5 E., sec. 25, and T. 8 S., R. 6 E., 8 sec. 30; iron post	561.021
Red River, meander corner on, between T. 8 S., R. 8 E., sec. 31, and T. 9 S., R. 8 E., sec. 6; iron post	529.316

FROM COLBERT, INDIAN TERRITORY, ALONG THE MISSOURI, KANSAS AND TEXAS RAILWAY, TO SHERMAN, TEXAS.

Colbert, Indian Territory, 2¾ miles south of; copper bolt set in first step of the north abutment of bridge over Red River, No. 451. The bolt is 1.3 feet from the north edge, 1 foot from the south edge, and 0.9 foot from the west edge	550.105
Denison, Texas; bronze tablet set in center of base stone of granite foundation of the Ford Building, on left of avenue entrance. The building is situated at corner of Main street and Rusk avenue, and is occupied by the National Bank of Denison and numerous offices	735.831
Cook Spring, Texas, near station; railroad spike in fifth telegraph pole south of mile-pole 666	641.821
Sherman, Texas; bronze tablet set in first course of stone foundation, 5.2 feet from south edge of stone, 5.8 feet from north edge of stone, and on the left side of main entrance to the Fire Department. The building is situated on the corner of Travis and Cherry streets	728.294

FROM CHOCTAW, TEXAS, WEST ALONG TEXAS AND PACIFIC RAILWAY, TO SOUTHMAYD, TEXAS.

Choctaw, Grayson County, about 1 mile west of; on anchor bolt at northeast corner of shoe of angle brace, on north side of bridge 72, over Choctaw Creek	578.262
Southmayd, Grayson County, 5 miles east of; iron post set 20 feet and 9 inches south of mile pole 160, and 48 feet and 3 inches south of center of Texas and Pacific track, and 249 feet west of road crossing	835.166
Southmayd, Grayson County; iron post set 9 feet south of mile pole 165, which pole is the fourth one west of station, and is 46 feet south of center of Texas and Pacific track	742.202

ALONG THE JOINT LINE OF TEXAS AND PACIFIC AND MISSOURI, KANSAS AND TEXAS RAILROADS.

Collinsville, Grayson County; iron post set 50 feet south of frog of switch, and 5 feet 10 inches east of center of track	745.504

FROM ETHEL, GRAYSON COUNTY, TEXAS, EAST ALONG COUNTY ROADS, TO HOWE, GRAYSON COUNTY, TEXAS.

	Feet.
Ethel, Grayson County; iron post set in the northeast corner of intersection of roads and on inside of fence	723.969
Ethel, Grayson County, about 6¼ miles east of; iron post set in northeast corner of intersection of the Sherman and Tioga road with the Sherman and Howe road, on the inside of fence	713.036
Howe, Grayson County, about 6½ miles west of; iron post set inside of fence at northeast corner of intersection of roads at William Chisholm's home	816.682
Howe, Grayson County; iron post set 19 feet 6 inches west of center of Houston and Texas Central Railroad and 49 feet 6 inches north of northeast corner of station building	841.264
Howe, Grayson County, about ⅘ mile south of; lead bolt in stone underneath the triangulation signal at Howe	877.515

ON HOUSTON AND TEXAS CENTRAL RAILROAD.

Sherman, Grayson County, 4 miles south of; copper bolt in lower coping stone west side of south abutment of bridge over Choctaw Creek	652.519

FROM SHERMAN, GRAYSON COUNTY, TEXAS, ALONG COUNTY ROAD NORTH TO POTTSBORO, GRAYSON COUNTY, TEXAS; THEN WEST TO DEXTER, COOKE COUNTY, TEXAS; THEN SOUTH TO WHITESBORO, GRAYSON COUNTY, TEXAS.

Pottsboro, Grayson County, 4¾ miles south of; copper bolt in stone underneath triangulation signal "Good"	881.225
Pottsboro, Grayson County, 6½ miles west of; iron post set in southeast corner of Mrs. Carrie Nicholas's front yard and 285 feet north of center of the Pottsboro-Gordonville road	714.245
Gordonville, Grayson County; iron post south of Sanderson's drug store, east of post-office, and 33 feet south of center of road, on widow Gordon's place, and nearly south of old well in roadway	719.345
Dexter, Cooke County, ¾ mile east of; iron post set in front garden of J. F. Evans, at a distance of 62.5 feet south of southwest corner of Evans's house and 63 feet north of center of main road, and about 200 feet west of the county line between Cooke and Grayson counties	835.985
Dexter, Cooke County; cross mark cut in the foundation stone at the southwest corner of J. F. Cochran's store. The building is owned by Mrs. T. H. Williams	779.515
Dexter, Cooke County, ½ mile north of; copper bolt in stone underneath "Dexter" triangulation station	861.8
Dexter, Cooke County, 5½ miles south of; iron post set at turn of road eastward around M. A. Goldston's pasture and about 1,165 feet south of house which is owned by the Carlock heirs and occupied by Mr. Stuckey. Bench mark on inside of fence	793.71
County line, Cooke County, 1⅝ miles west of; copper bolt in stone underneath "County line" triangulation signal	882.345
Whitesboro, Grayson County, 3⅜ miles west of; iron post at intersection of the Dexter road with the Gainesville-Whitesboro road, set in the corner of Dr. Younger's yard and across the road from Nance Prairie *school*	772.215

FROM SOUTHMAYD, GRAYSON COUNTY, TEXAS, SOUTHEAST ON COUNTY ROAD TO MORMON GROVE, GRAYSON COUNTY, TEXAS, THEN NORTHEAST TO SHERMAN, TEXAS.

	Feet.
Southmayd, Grayson County, 6¼ miles southeast of; iron post about 1¼ miles south of Valley Summit School and set in Halliday's field, across the road from Mrs. Keene's pasture. It is about 20 feet east of the center of road and 2 feet north of division fence, while the head of a timbered drain flowing southwest is 600 feet north	758.61
Mormon Grove, Grayson County, 550 feet northeast of; cross mark cut in stone underneath "Mormon Grove" triangulation station. The copper bolt in the stone is about 2 feet under the surface, and was put there by the triangulation party	899.255
Sherman, Grayson County, 3 miles southwest of; iron post set on inside of fence at a turn of the road to the east and directly opposite a gate on the other side of the lane	799.985

ALONG COUNTY ROAD FROM POTTSBORO, GRAYSON COUNTY, TEXAS, TO MEANDER CORNER ON RED RIVER OF T. 8 S., RS. 5 AND 6 E., OF THE CHICKASAW SURVEY.

Fink, Grayson County; iron post set inside of fence, 24 feet north of road to Bounds Ferry and just west of the post-office	708.715
Fink, Grayson County, 2 miles west of; copper bolt in stone underneath "Fink" triangulation station	837.92

DENISON, TEXAS.

Iron post at headquarters of the United States Geological Survey, Indian Territory division, on the corner of Texas street and Austin avenue. The post is set in the front yard, near the gate opening on Texas street, the property being known as "The Stuart place"	755.355

ALONG THE MISSOURI, KANSAS AND TEXAS RAILWAY, FROM POTTSBORO, TEXAS, WEST TO WOODBINE, TEXAS.

Pottsboro, Grayson County; bronze tablet set in foundation stone of southwest corner of brick and stone building owned and occupied by J. E. Reeves	765.919
Steedman, Grayson County; iron post, 1 foot above the surface, 50 feet south of track and 100 feet east of the section house at Steedman. Name of railroad station is Deaver	630.123
Whitesboro, Grayson County; bronze tablet, 3.5 feet above ground and 15 inches from southeast corner on east side of brick school building at Whitesboro	819.764
Woodbine, Grayson County, 2 miles east of; cross mark cut on southwest end of coping stone on south side of east end bridge over Timber Creek and about 30 feet from mile-pole 691	697.764

GAINESVILLE QUADRANGLE (TEXAS-INDIAN TERRITORY).

The railroad levels were run by Messrs. R. T. Carnall and R. Coe. Mr. J. H. Carlock was attached to the topographic and subdivision party of Mr. C. W. Goodlove, and Mr. R. T. Carnall was with Mr. J. Ahern's party.

GAINESVILLE, TEXAS.

	Feet.
Bronze tablet set in center of north face of top foundation stone at northeast corner of brick building on California street, near station building, and used by Tyler & Simpson as a grocery store	733.159
Iron post, 2 inches out of ground, 45.3 feet south of south crossing frog, and in line with north and south crossing frogs of the Missouri, Kansas and Texas Railway with the Gulf, Colorado and Santa Fe Railway. It is 6.4 feet west of west rail of Missouri, Kansas and Texas and 6.8 feet east of east rail of Gulf, Colorado and Santa Fe	740.188

FROM GAINESVILLE, TEXAS, ALONG GULF, COLORADO AND SANTA FE RAILWAY TO MARIETTA, INDIAN TERRITORY.

Gainesville, Texas, 6 miles north of; copper bolt set about middle of coping stone on east side of north pier of bridge over Red River	660.541
Thackerville, Indian Territory, 1 mile north of; railroad spike in first telegraph pole north of mile pole 424	880.606
Bomer, Indian Territory, railroad spike in telegraph mile pole 428	826.439
Marietta, Indian Territory, bronze tablet set about the middle of east face of second stone above foundation at northeast corner of two-story stone building owned by S. S. Evants and used by him as a general store	844.640

ALONG TOWNSHIP AND SECTION LINES.

Corner Ts. 6 and 7 S., Rs. 2 and 3 W., iron post	921.010
Corner Ts. 6 and 7 S., Rs. 1 and 2 W., iron post	770.248
Corner Ts. 6 and 7 S., Rs. 1 W. and 1 E., iron post	917.328
Corner Ts. 6 and 7 S., Rs. 1 and 2 E., iron post	796.318
Corner Ts. 6 and 7 S., Rs. 2 and 3 E., iron post	662.478
Corner Ts. 7 and 8 S., Rs. 2 and 3 E., iron post	737.336
Corner Ts. 7 and 8 S., Rs. 1 and 2 E., iron post	779.936
Red River, meander corner on, between sec. 34, T. 7 S., R. 1 E. and sec. 3, T. 8 S., R. 1 E., on stone	670.696
Red River, meander corner on, between sec. 31, T. 7 S., R. 1 E., and sec. 36, T. 7 S., R. 1 W., on stone	675.968
Red River, meander corner on, between sec. 36, T. 7 S., R. 1 W., and sec. 1, T. 8 S., R. 1 W., iron post	677.483
Corner Ts. 7 and 8 S., Rs. 1 and 2 W., iron post	827.208
Red River, meander corner on, between sec. 31, T. 7 S., R. 2 W., and sec. 6, T. 8 S., R. 2 W., iron post	720.700
Red River, meander corner on, between sec. 31, T. 7 S., R. 2 W., and sec. 36, T. 7 S., R. 3 W., iron post	722.500
Red River, meander corner on, between sec. 13, T. 8 S., R. 2 W., and sec. 18, T. 8 S., R. 1 W., iron post	696.800
Red River, meander corner on, between sec. 34, T. 8 S., R. 1 E., and sec. 3, T. 9 S., R. 1 E., on stone	658.536
Corner Ts. 8 and 9 S., Rs. 1 and 2 E., iron post	664.556
Red River, meander corner on, between sec. 34, T. 8 S., R. 2 E., and sec. 3, T. 9 S., R. 2 E., on stone	627.506
Red River, meander corner on, between sec. 24, T. 8 S., R. 2 E., and sec. 19, T. 8 S., R. 3 E., on stone	612.286

MONTAGUE QUADRANGLE (TEXAS-INDIAN TERRITORY).

Mr. R. Coe ran the railroad levels. Mr. J. P. Walker was attached to the subdivision and topographic party of Mr. A. D. Morton and Mr. R. Coe to that of Mr. J. Ahern's.

FROM RYAN, ALONG THE CHICAGO, ROCK ISLAND AND PACIFIC RAILWAY, TO TERRAL.

	Feet.
Ryan, 2½ miles south of; a railroad spike in mile pole 513	840.443
Terral, at north end of siding; railroad spike in mile pole 519	844.706
Terral, 1 mile south of; a copper bolt in the west end of north pier of bridge 3219 over Red River	808.837

ALONG TOWNSHIP AND SECTION LINES.

Red River, meander corner on, between sec. 32, T. 6 S., R. 7 W., and sec. 5, T. 7 S., R. 7 W., iron post	814.696
Corner Ts. 6 and 7 S., Rs. 6 and 7 W., iron post	928.723
Corner Ts. 6 and 7 S., Rs. 5 and 6 W., iron post	854.532
Red River, meander corner on, between sec. 35, T. 6 S., R. 5 W., and sec. 2, T. 7 S., R. 5 W., iron post	763.381
Red River, meander corner on, between sec. 33, T. 6 S., R. 4 W., and sec. 4, T. 7 S., R. 4 W., iron post	749.0
Corner Ts. 6 and 7 S., Rs. 3 and 4 W., iron post	809.955
Red River, meander corner on, between sec. 31, T. 7 S., R. 3 W., and sec. 36, T. 7 S., R. 4 W., iron post	730.9
Red River, meander corner on, between sec. 35, T. 7 S., R. 6 W., and sec. 2, T. 8 S., R. 6 W., iron post	773.92
Corner Ts. 7 and 8 S., Rs. 6 and 7 W., iron post	887.629
Red River, meander corner on, between sec. 31, T. 7 S., R. 7 W., and sec. 6, T. 8 S., R. 7 W., iron post	800.916
Red River, meander corner on, between sec. 18, T. 8 S., R. 6 W., and sec. 13, T. 8 S., R. 7 W., iron post	793.836

ADDINGTON, RUSH SPRINGS, AND CHICKASHA QUADRANGLES.

The leveling was done by Mr. W. A. Lindsay, under the general direction of Mr. E. M. Douglas.

ALONG NINETY-EIGHTH MERIDIAN, BETWEEN RED AND CANADIAN RIVERS.

	Feet.
Initial point, concrete pier, marked "854"	854.445
Milepost No. 1, marked "913"	913.148
Milepost No. 2, marked "927"	926.937
Milepost No. 3, marked "863"	863.152
Milepost No. 4, marked "889"	900.306
Milepost No. 5, marked "933"	933.402
Milepost No. 6, marked "910"	910.077
Milepost No. 7, marked "868"	868.095
Milepost No. 8, marked "882"	881.942
Milepost No. 9, marked "868"	868.035
Milepost No. 10, marked "875"	874.803

	Feet.
Milepost No. 11, marked "883"	882.747
Milepost No. 12, marked "884"	883.811
Milepost No. 13, marked "895"	893.694
Milepost No. 14, marked "897"	897.435
Milepost No. 15, marked "931"	931.307
Milepost No. 16, marked "973"	973.505
Milepost No. 17, marked "979"	979.186
Milepost No. 18, marked "972"	971.815
Milepost No. 19, marked "939"	939.450
Milepost No. 20, marked "945"	945.447
Milepost No. 21, marked "1007"	1,007.407
Milepost No. 22, marked "1017"	1,017.701
Milepost No. 23, marked "1034"	1,034.313
Milepost No. 24, marked "1034"	1,033.938
Milepost No. 25, marked "1054"	1,054.209
Milepost No. 26, marked "1075"	1,075.657
Milepost No. 27, marked "1074"	1,074.173
Milepost No. 28, marked "1070"	1,070.598
Milepost No. 29, marked "1127"	1,127.602
Milepost No. 30, marked "1135"	1,135.599
Milepost No. 31, marked "1143"	1,143.029
Milepost No. 32, marked "1121"	1,121.527
Milepost No. 33, marked "1104"	1,103.753
Milepost No. 34, marked "1137"	1,137.530
Milepost No. 35, marked "1144"	1,144.152
Milepost No. 36, marked "1147"	1,147.096
Milepost No. 37, marked "1170"	1,169.849
Milepost No. 38, marked "1211"	1,211.093
Milepost No. 39, marked "1213"	1,212.849
Milepost No. 40, marked "1206"	1,206.236
Milepost No. 41, marked "1151"	1,151.08
Milepost No. 42, marked "1196"	1,195.923
Milepost No. 43, marked "1204"	1,203.528
Milepost No. 44, marked "1237"	1,236.832
Milepost No. 45, marked "1269"	1,269.383
Closing corner, Ts. 2 and 3 N., R. 8 W., marked "1244"	1,244.261
Milepost No. 46, marked "1243"	1,243.125
Milepost No. 47, marked "1235"	1,234.873
Milepost No. 48, marked "1241"	1,240.775
Milepost No. 49, marked "1260"	1,259.76
Milepost No. 50, marked "1297"	1,297.334
Milepost No. 51, marked "1279"	1,279.132
Milepost No. 52, marked "1357"	1,356.585
Closing corner, T. 3 N., R. 8 W., marked "1361"	1,360.641
Corner, Ts. 3 and 4 N., Rs. 7 and 8 W., marked "1362"	1,362.187
Milepost No. 53, marked "1365"	1,365.486
Milepost No. 54, marked "1356"	1,356.359
Milepost No. 55, marked "1335"	1,334.913
Milepost No. 56, marked "1308"	1,307.751
Milepost No. 57, marked "1256"	1,255.771
Milepost No. 58, marked "1328"	1,328.026
Standard corner, T. 5 N., Rs. 7 and 8 W., marked "1333"	1,332.686
Closing corner, T. 4 N., Rs. 7 and 8 W., marked "1307"	1,306.843

	Feet.
Milepost No. 59, marked "1267"	1, 267. 095
Milepost No. 60, marked "1232"	1, 232. 503
Milepost No. 61, marked "1127"	1, 126. 587
Milepost No. 62, marked "1114"	1, 113. 541
Milepost No. 63, marked "1185"	1, 185. 222
Milepost No. 64, marked "1174"	1, 173. 947
Corner, Ts. 5 and 6 N., Rs. 7 and 8 W., marked "1130"	1, 130. 09
Milepost No. 65, marked "1176"	1, 175. 871
Milepost No. 66, marked "1245"	1, 245. 524
Milepost No. 67, marked "1282"	1, 281. 734
Milepost No. 68, marked "1181"	1, 181. 33
Milepost No. 69, marked "1217"	1, 216. 582
Milepost No. 70, marked "1188"	1, 188. 36
Milepost No. 71, marked "1207"	1, 207. 293
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Milepost No. 74, marked "1098"	1, 098. 02
Milepost No. 75, marked "1116"	1, 115. 786
Milepost No. 76, marked "1160"	1, 159. 796
Corner, Ts. 7 and 8 N., Rs. 7 and 8 W., marked "1158"	1, 158. 19
Milepost No. 77, marked "1197"	1, 197. 099
Milepost No. 78, marked "1185"	1, 184. 805
Milepost No. 79, marked "1177"	1, 177. 117
Milepost No. 80, marked "1210"	1, 209. 745
Milepost No. 81, marked "1259"	1, 259. 31
Milepost No. 82, marked "1290"	1, 290. 089
Closing corner, Ts. 8 and 9 N., R. 8 W., fractional, on second standard parallel north, marked "1293"	1, 293. 545
Standard corner, T. 9 N., Rs. 7 and 8 W., marked "1239"	1, 239. 036
Closing corner, T. 8 N., Rs. 7 and 8 W., marked "1234"	1, 233. 829
Milepost No. 83, marked "1293"	1, 292. 959
Milepost No. 84, marked "1294"	1, 294. 479
Milepost No. 85, marked "1307"	1, 307. 274
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Milepost No. 88, marked "1327"	1, 327. 309
Corner, Ts. 9 and 10 N., Rs. 7 and 8 W., marked "1408"	1, 408. 496
Milepost No. 98, marked "1301"	1, 300. 578
Milepost No. 90, marked "1366"	1, 366. 462
Milepost No. 91, marked "1402"	1, 402. 437
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UNITED STATES GEOLOGICAL SURVEY

CHARLES D. WALCOTT, DIRECTOR

SOME PRINCIPLES AND METHODS

OF

ROCK ANALYSIS

BY

WILLIAM FRANCIS HILLEBRAND

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LETTER OF TRANSMITTAL.

DEPARTMENT OF THE INTERIOR,
UNITED STATES GEOLOGICAL SURVEY,
Washington, D. C., July 13, 1900.

SIR: I herewith submit, with a request for its publication as a bulletin of the United States Geological Survey, a manuscript dealing in very considerable detail with the subject of silicate rock analysis, with special regard to the practice in the Survey laboratory. It represents, in largely rewritten and much extended form, that portion of Bulletin 148 which dealt with the same subject. The present publication seems fully justified by the demand on the part of mineral chemists for Bulletin 148, the supply of which available for sale has been exhausted.

Very respectfully,

W. F. HILLEBRAND,
Chemist.

Hon. CHARLES D. WALCOTT,
Director United States Geological Survey.

SOME PRINCIPLES AND METHODS OF ROCK ANALYSIS.

By W. F. HILLEBRAND.

PART I.—INTRODUCTION.

I. IMPORTANCE OF COMPLETE AND THOROUGH ANALYSES.

The composition of the ultimate ingredients of the earth's crust—the different mineral species which are there found and of many of which its rocks are made up—was the favorite theme of the great workers in chemistry of the earlier half of this century, and for the painstaking care and accuracy of Berzelius, Wöhler, and others the mineralogists and geologists of to-day have need to be thankful. Considering the limited facilities at their disposal in the way of laboratory equipment and quality of reagents, the general excellence of their work is little short of marvelous. As an outgrowth of and closely associated with the analysis of minerals came that of the more or less complex mixtures of them—the rocks—to aid whose study by the petrographer and geologist a host of chemists have for many decades annually turned out hundreds of analyses of all grades of quality and completeness. With the growth and extraordinary development of the so-called organic chemistry inorganic chemistry gradually fell into a sort of disfavor. In many, even the best, European laboratories, the course in mineral analysis, while maintained as a part of the curriculum of study, became but a subordinate prelude to the ever-expanding study of the carbon compounds, whose rapid multiplication, offering an easy and convenient field for original research and possible profit, proved a more tempting opening to young chemists than the often-worked-over and apparently exhausted inorganic pasture. For one student devoting his time to higher research on inorganic lines were perhaps fifty engaged in erecting the present enormous structure of carbon chemistry. The instruction afforded the student in mineral analysis

was confined to the ordinary separations of the commoner ingredients occurring in appreciable quantities, with little regard to supposed traces and with still less attempt to find out if the tabulated list really comprised all that the mineral or rock contained.

With the introduction of improved methods of examination by the petrographer, especially as applied to thin rock sections, and the use of heavy solutions, whereby, on the one hand, the qualitative mineral composition of a rock could be preliminarily ascertained with considerable certainty, and on the other, chemical examination of the more or less perfectly separated ingredients was rendered possible, a great help and incentive was afforded to the few chemists engaged in rock analysis. The microscope often obviated in part the necessity for tedious and time-wasting qualitative tests, and the heavy solutions, by permitting the concentration and separation of certain components, facilitated the detection of elements whose existence had long been overlooked.

Meanwhile in the progress of chemistry new methods and reagents for qualitative detection and quantitative separation and estimation were gradually being discovered and devised. The supposed adequacy of some well-established methods was shown to be unwarranted; some had to be discarded altogether; others were still utilizable after modification. In the light thus shed it became possible to explain many hitherto incomprehensible variations in the composition of some rock species or types, as shown in earlier analyses, and in not a few cases it appeared that the failure to report the presence of one or more elements had obscured relations and differences which more thorough examination showed to exist (see pp. 16–17). Consequently there arose a feeling of distrust of much of the older work in the minds of those chemists and petrographers best fitted to judge of its probable qualities. This, and the incompleteness of nearly all the earlier work (and much of that of to-day, unfortunately), as shown by the largely increased list of those elements now known to enter into the normal composition of rocks, is rendering the old material less and less available to meet the increasing demands of the petrographer.

And yet these demands on his part are, with few exceptions, by no means so exacting as they should be. Often the analysis is intrusted to the hands of a student without other experience than that gained by the analysis of two or three artificial salts and as many comparatively simple natural minerals, and with a laboratory instructor as adviser whose experience in rock analysis may be little superior to his own. In other words, one of the most difficult tasks in practical analysis is expected to be solved by a tyro, and his results are complacently accepted and published broadcast without question. Even to those thoroughly familiar with the subject rock analysis is a complex and

often trying problem. Although long practice may have enabled one to do certain parts of it almost mechanically, one is still from time to time confronted with perplexing questions which require trained judgment to properly meet and answer, and there is still room for important work in some of the supposedly simplest quantitative determinations. If the results are to have any decided value for purposes of scientific interpretation and comparison, they should be the product of one competent to find his way through the intricacies of an analysis in which from fifteen to twenty-five different components are to be separated and estimated with close approach to accuracy, and this a beginner can not hope to do in the majority of cases. The conscientious chemist should have a live interest in this matter. He should work with a twofold purpose in view—that of lightening the labors of those who come after him by enabling them to use his work with less supplementary examination and of thereby enhancing his own reputation by meriting encomiums on work that has stood the test of time.

The petrographer, again, should seek to have his analyses made as complete as possible, and not, as is so often the case, be content with determinations of silica, alumina, the oxides of iron, lime, magnesia, the alkalies, and water. The latter, it is true, are entirely justifiable at times, and may serve the immediate purpose for which they were intended, but their incompleteness may, on the other hand, not only conceal points fruitful of suggestion to the attentive mind, but, what is of still greater importance, they may be actually misleading. Enough instances of totally inaccurate conclusions to be drawn from them have fallen under my own observation to fully justify this plea in favor of greater completeness in rock and mineral analyses made for purely scientific purposes.

The importance of the points indicated in the foregoing paragraph is shown by the difference between the analyses given on the following page. The specimens were taken and analyzed at widely separated times and by different persons, it is true, but they were unquestionably from the same rock mass, in which, however much the relative proportions of the different mineral constituents might vary within certain limits, there can be no reason to doubt the general distribution of all the elements shown by the second analysis.

	Earlier analysis.	Later analysis. *a*
SiO_2	54.42	53.70
TiO_2	.....	1.92
Al_2O_3	13.37	11.16
Cr_2O_3	.....	.04
Fe_2O_3	*b* .61	3.10
FeO	*b* 3.52	1.21
MnO	.....	.04
CaO	4.38	3.46
SrO	.....	.19
BaO	.....	.62
MgO	6.37	6.44
K_2O	10.73	11.16
Na_2O	1.60	1.67
Li_2O	Trace.	Trace.
H_2O below 110° C.	.....	.80
H_2O above 110° C.	*c* 2.76	2.61
CO_2	1.82	.....
P_2O_5	.....	1.75
SO_3	.....	.06
F	.....	.44
Cl	.....	.03
	99.58	100.40
Less O for F	.....	.19
		100.21

a A still more recent analysis of another of the series of rocks of which this is an example has shown that this "later analysis" is itself probably incomplete and incorrect in part—incomplete because of the probable presence of 0.2 per cent or more of ZrO_2, incorrect because of the error in Al_2O_3 resulting from having counted the ZrO_2 as Al_2O_3, and from the fact that titanium is not fully precipitable in presence of zirconium by Gooch's method (the one employed). This latter error involves both the TiO_2 and the Al_2O_3. (See pp. 72–73.)

b From the fact that repeated determinations of the iron oxides in this and related rocks from the same region show always a great preponderance of ferric oxide, it is not improbable that the figures given for the two oxides in the first analysis were accidentally transposed.

c In the published analysis it does not appear whether this is total water or, as seems probable, only that remaining above 100° C.

Another instance of similar kind is given below. Here, again, certain differences are explainable by natural variations in the proportions of the constituent minerals, but it can hardly be doubted that TiO_2, BaO, SrO, P_2O_5, and SO_3 were present in both specimens in approximately the same amounts. In the earlier analysis determinations of some supposed unimportant constituents were purposely omitted, or made only qualitatively, with results that can not be otherwise than fatal to a full comprehension of the mineralogical nature of the rock.

	Earlier analysis.	Later analysis.
SiO_2	44.31	44.65
TiO_2	Not est.	.95
Al_2O_3	17.20	13.87
Fe_2O_3	4.64	6.06
FeO	3.73	2.94
MnO	.10	.17
CaO	10.40	9.57
SrO	.....	*a*.37
BaO	.....	.76
MgO	6.57	5.15
K_2O	3.64	4.49
Na_2O	4.45	5.67
Li_2O	.....	Trace.
H_2O below 110° C.	.77	.95
H_2O above 110° C.	.....	2.10
H_2O by ignition	3.30	.....
CO_2	.....	.11
P_2O_5	.....	1.50
Cl	.....	Trace.
SO_3	.....	.61
	99.11	99.92

a Not entirely free from CaO.

Prof. F. W. Clarke has shown that the combined percentages of titanic and phosphoric oxides in rocks of the earth's crust, averaged from hundreds of analyses, is 0.8 per cent. When the determination of these is neglected the error falls upon the alumina. If the latter is then used as a basis for calculating the feldspars, it is easy to see that a very large average error in the latter may result, amounting to several per cent of the rock.

In order to more strongly emphasize the importance of completeness in analysis, a few facts brought out by the hundreds of rock analyses made in this laboratory may be cited. It has been demonstrated most conclusively that barium and strontium are almost never-failing constituents of the igneous rocks of the United States and of many of their derivatives. These amounts are usually below 0.1 per cent for each of the oxides of those metals, but higher amounts are by no means uncommon. Furthermore, the weight of barium is almost without exception in excess of that of strontium. But a still more important point is that the igneous rocks of the Rocky Mountain region, so far as examined, show far higher average percentages of

both metals than the rocks from the eastern and the more western portions of the United States. The following examples serve to illustrate certain types of Rocky Mountain igneous rocks: Of seven rocks forming a Colorado series, six held from 0.13 to 0.18 per cent of BaO, while in the seventh the percentage was 0.43. The SrO ranged from 0.07 to 0.13 per cent for six, and was 0.28 for that one highest in BaO. Of thirteen geologically related rocks from Montana, embracing basic as well as acid and intermediate types, the range of BaO was from 0.19 to 0.37 per cent, with an average of 0.30 per cent. Three others of the same series contained 0.10 per cent or less, while the seventeenth carried 0.76 per cent BaO. The SrO ranged from 0.37 per cent in the last instance to an average of 0.06 for the other sixteen. Certain peculiar rocks from Wyoming carry from 0.62 to 1.25 per cent BaO, and from 0.02 to 0.33 per cent SrO. Surely this concentration of certain chemical elements in certain geographic zones has a significance which future geologists will be able to interpret, if those of to-day are not.

Again, vanadium is an element which few chemists have ever thought of looking for in igneous rocks, though it has long been known to occur in magnetites and other iron ores. Hayes, in 1875, reported its occurrence in a great variety of rocks and ores. Quoting from Thorpe's Dictionary of Chemistry: "It is said to be diffused with titanium through all primitive granite rocks (Dieulafait), and has been found by Deville in bauxite, rutile, and many other minerals, and by Bechi and others in the ashes of plants and in argillaceous limestones, schists, and sands." It is further reported to comprise, as the pentoxide, up to 0.1 per cent of many French and Australian clays, 0.02–0.03 per cent of some basalts, 0.24 per cent of a coal of unknown origin, and 0.45 per cent of one from Peru. Still later examinations in this laboratory of about 100 rocks, chiefly igneous, covering the whole territory of the United States, show not only its general qualitative and quantitative distribution, but that it predominates in the less siliceous igneous rocks and is absent, or nearly so, in those high in silica. In some of the more basic rocks it occurs in sufficient amount to seriously affect the figures for the oxides of iron unless separately estimated and allowed for (see p. 96)—a matter of considerable importance, since the petrographer lays great stress on accuracy in their determinations.

This same investigation has also thrown some light on the distribution of molybdenum, which seems to be confined to the more siliceous rocks and to occur in quantities far below those commonly found for vanadium.

Finally, had it not been the writer's practice of late years to look for sulphur in rocks, even when no sulphides were visible to the eye, *its almost invariable* presence in the form of sulphide, and consequent

connection with the long mystifying lack of agreement between results for ferrous iron obtained by the Mitscherlich and the hydrofluoric-acid methods, might not have been suspected. (See p. 89.)

While strongly upholding the necessity for more thorough work, necessarily somewhat at the expense of quantity, it is far from the writer's intention to demand that an amount of time altogether disproportionate to the immediate objects to be sought should be expended on every analysis. But it is maintained that in general the constituents which are likely to be present in sufficient amount to admit of determination in the weight of sample usually taken for analysis—say 1 gram for SiO_2, Al_2O_3, etc., to 2 grams for certain other constituents—should be sought for, qualitatively at least, in the ordinary course of quantitative work, and their presence or absence noted among the results. If present in little more than traces, that knowledge alone may suffice, for it is often more important to know whether or not an element is present than to be able to say that it is there in amount of exactly 0.02 or 0.06 per cent. In the tabulation of analyses a special note should be made in case of intentional or accidental neglect to look for substances which it is known are likely to be present. Failure to do this may subject the analyst to unfavorable criticism, when at some future time his work is reviewed and the omissions are discovered by new analyses.

Finally, whenever possible, a thorough microscopical examination of the rock in thin section should precede the chemical analysis. This may be of the greatest aid to the chemist in indicating the presence of unusual constituents, or of more than customary amounts of certain constituents, whereby, possibly, necessary modifications in the analytical procedure may be employed without waste of time or labor.[1]

II. OBJECT AND SCOPE OF THE PRESENT TREATISE.

The literature relating to analysis of silicates is extensive but scattered, and in no single article is there to be found a satisfactory exposition of the methods to be followed or the precautions to be observed, especially in the search for some of the rarer constituents or those which, without being rare, have been of late years recognized as occurring persistently in small amounts. It is not intended to make this little volume a treatise on mineral analysis, but it is believed that the experience gained by the chemists of this Survey during the twenty years since the establishment of its first chemical laboratory

[1] The foregoing tables and accompanying remarks, including several sentences preceding the tables, have been largely taken from the writer's papers entitled "A plea for greater completeness in chemical rock analysis," published in the Journal of the American Chemical Society, Vol. XVI, pp. 90–93, 1894; also in the Chemical News, Vol. LXIX, p. 163, 1894. See also "Distribution and quantitative occurrence of vanadium and molybdenum in rocks of the United States," in the American Journal of Science, 4th series, Vol. VI, p. 209, 1898, and Chemical News, Vol. LXXVIII, p. 216, 1898.

in Denver may be useful to most chemists interested in mineral and especially rock analysis.

The original publication of these data in Bulletin No. 148 was primarily intended to show the principles and methods according to which the major part of the very many hundreds of analyses therein brought together had been executed, and thus to furnish a partial measure of the trustworthiness of those analyses, rather than to serve as a practical manual of rock analysis. But the use which has been made by mineral chemists of that bulletin has seemed to render it advisable to amplify somewhat in detail and to add, besides a few new methods, a number of alternative ones which are known or believed to be good, in order that those who may wish to use this treatise as a practical guide shall have a choice from which to select in case the rather expensive apparatus or complicated arrangements sometimes preferred are not available. Where silicate analyses are very frequently made, however, it is a saving of time and of money in the end to set up permanent arrangements for convenience in estimating water, carbon dioxide, ferrous iron, making reductions in hydrogen, etc.

Stress will be laid on those points meriting particular attention, and now and then a brief discussion or criticism of methods elsewhere in vogue may be entered into.

In the earlier years of the existence of the Washington laboratory opportunity was afforded for the testing of novel methods and the devising of new ones, with most excellent results, as shown especially by the methods for separation of titanium, of lithium, and of boron, due to Prof. F. A. Gooch, to whose inventive skill chemists owe likewise the perforated filtering crucible and the tubulated platinum crucible arrangement for the estimation of water. Of late years the press of routine work has been such as to more fully fill up the time of the much-reduced chemical force, and as a consequence it has been found impossible to subject to critical trial several separation methods of recent origin, some of which seem to be full of promise, or to follow out certain lines of investigation which have been suggested by the observations made in this laboratory. This, then, must be offered in explanation if, in the following discussion, it may seem to some that any of the methods followed are too conservative. In general the discussion will be confined strictly to such separations as may be required in the analysis of an igneous, metamorphic, or sedimentary silicate rock of complex mineralogical composition, in which the majority and possibly all of the ingredients in the list given below may occur in weighable or readily discoverable quantities:

SiO_2, TiO_2, ZrO_2, Al_2O_3, Fe_2O_3, Cr_2O_3, V_2O_3, FeO, MnO, NiO, CoO, MgO, CaO, SrO, BaO, ZnO, CuO, K_2O, Na_2O, Li_2O, H_2O, P_2O_5, S,[1] SO_3 C,[2] CO_2, Fl, Cl, N.

The special problems often arising in the analysis of rocks of extra-

[1] *Usually as pyrite*, not infrequently as pyrrhotite.

[2] As graphite or coaly matter.

terrestrial origin—the more or less stony meteorites—will not be considered. An analysis of that kind should never be intrusted to the novice, but only to the chemist who has a knowledge of the composition and properties of the peculiar mineral constituents of those bodies and a judgment fit to cope with the oftentimes difficult problems presented by them.

Thorium, cerium, and other rare earths are seldom encountered in quantities sufficient to warrant the expenditure of the time necessary for their isolation. A search for them qualitatively, even, is at present rarely justifiable unless there is microscopic or other evidence of the presence of minerals likely to contain them. Tantalum, columbium, boron, and glucinum have never been certainly met with in the writer's experience, and yet they must be present in certain rocks, and doubtless traces have been overlooked at times. There is no reason to suppose that other elements may not be found by careful search, possibly all in the known category, and, indeed, Sandberger's researches have shown to what an extent this is true of a large number of those elements contributing to the filling of metalliferous veins. But those in the above list may usually be estimated with ease in weights of from one-half to 2 grams.

If the point be raised that many of the published analyses emanating from the Survey laboratories, even the earlier ones of the writer, are not in accord with the advocacy of completeness contained in the foregoing pages, it may be remarked that these ideas have been to a considerable degree evolved during a personal experience of twenty years in this line of work, and that frequently the exigencies were such as to compel restriction in the examination. Where the latter has been the case subsequent developments have in some cases shown it to be bad policy in every respect. It is better, both for the geologist and the chemist, to turn out a limited amount of thorough work than a great deal of what may prove to be of more than doubtful utility in the end.

III. STATEMENT OF ANALYSES.

Until recently it has been the practice in this laboratory to tabulate the constituents of a rock somewhat in the order of their determination, beginning with SiO_2 as the chief constituent and grouping together all chemically related oxides, as shown, for instance, on pages 16 and 17.

From a strictly scientific point of view a chemical classification founded on a separation into basic and acidic atoms or radicals would be more satisfactory, but until we learn to find out what silicic radicals are present and in what relative amounts, also how much free silica there may be, it is useless to think of employing the arrangement so valuable in stating water analyses.

Of late petrographers have begun to demand, with considerable reason, an arrangement "which shall bring the essential chemical features—both the percentage figures and the molecular ratios—prominently and compactly before the eye, so that the general chemical character and the relations of the various constituents may be seen at a glance."[1]

In accordance with this demand it is now our practice to follow pretty closely the arrangement proposed by Pirsson and very recently strongly advocated by Washington (loc. cit.), namely:

SiO_2, Al_2O_3, Fe_2O_3, FeO, MgO, CaO, Na_2O, K_2O, H_2O (above 105–110° C.), H_2O (below 105–110° C.), CO_2, TiO_2, ZrO_2, P_2O_5, SO_3, Cl, Fl, S (FeS_2), Cr_2O_3, V_2O_3, NiO, CoO, CuO, MnO, SrO, BaO, Li_2O, C, NH_3.

By this arrangement the nine constituents which in the great majority of cases determine the character of the rock are placed at the head of the list, thus greatly facilitating the comparison of different analyses similarly arranged, especially when, as Washington recommends, the molecular ratios are calculated for these leading constituents and placed immediately after the corresponding oxides. The order of the remaining members is determined somewhat by the following considerations: CO_2 is placed next after H_2O, since these two are generally a measure of the alteration the rock may have undergone. TiO_2 and ZrO_2 naturally follow CO_2 on chemical grounds, and SO_3 and Cl, being common constituents of the sodalite group, are conveniently placed together.

IV. TIME NEEDED FOR MAKING AN ANALYSIS.

The question has often been put, "How long does it take to complete an analysis of this kind?" This will depend, of course, on the mineral complexity of the sample and on the personal factor of the individual worker. If there is a competent assistant to do the grinding, and specific-gravity determinations are not required, it is quite possible after long experience for a quick worker to learn to so economize every moment of time in a working day of seven hours, with an abundance of platinum utensils and continuous use of air and water baths through the night, as to finish every three days, after the completion of the first analysis, barring accidents and delays, one of a series of rocks of generally similar character, each containing from eighteen to twenty quantitatively determinable constituents, excluding, for instance, fluorine, carbon as such, nitrogen, metals of the hydrogen sulphide group, and cobalt. On one occasion a series of fourteen rocks, of comparatively simple composition, was completed in one month, with the help of an assistant who made the phosphorus

[1] *H. S. Washington*, The statement of rock analyses: Am. Jour. Sci., 4th series, Vol. X, p. 61, 1900.

and ferrous iron determinations. But such an output of work is more than exceptional and implies an unusual freedom from those occasional setbacks to which every chemist is exposed.

It should here be remarked that the Survey laboratory is most exceptionally well supplied with all kinds of platinum vessels and utensils, so that it is rare indeed for delay to arise through lack of dishes of even the largest sizes.

V. TWO USEFUL AIDS IN CHEMICAL MANIPULATION.

In connection with the foregoing remarks it is in place to mention two aids to the chemist which are in constant use in this laboratory and have come to be well-nigh indispensable. Neither is novel in principle and both are in use elsewhere, but they are not so commonly known as they deserve to be, hence this allusion to them.

Fig. 1 represents a form of platinum-tipped crucible tongs devised by Dr. A. A. Blair many years ago. With them a crucible can be securely grasped and brought into any desired position while still hot. To the contents, if in fusion over the blast flame, can be imparted the rotatory motion so often desirable. Above all, the cover need not be in the slightest degree displaced, as when using the common form of platinum-tipped tongs.

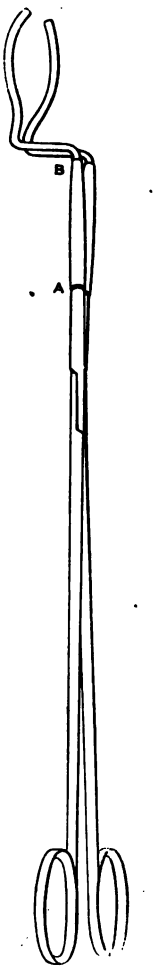

FIG. 1.—Platinum-tipped crucible tongs. The parts A B, also of heavy platinum, are hollow, to serve as sockets for the cheaper metal of the handles.

Fig. 2 represents a very useful adjunct to the worktable and especially to the draught cupboard, whereby the liquid contents of crucibles can be speedily evaporated at almost any desired temperature and the dehydration of many solids effected much more safely than on an iron plate or sand bath. I do not recall who originated this form of air bath, but it has been in use here for over fifteen years and is identical in principle with the later Nickel-becher of Jannasch. Nickel undoubtedly has a certain advantage in not rusting as does iron, but the form depicted in R of fig. 2 can easily be made anywhere of sheet iron riveted at the joint, the bottom (not shown in the figure) being securely held by a flange at the extremity of the truncated cone. A crucible placed on the platinum triangle becomes uniformly heated by hot air, and large quantities of liquid, even sulphuric acid, can be thus volatilized in a short time without ebullition or spattering.

VI. LIMITS OF ALLOWABLE ERROR IN SUMMATION OF ANALYTICAL RESULTS.

As is well known, a complete silicate rock analysis which foots up less than 100 per cent is generally less satisfactory than one which shows a summation somewhat in excess of 100. This is due to several causes. Nearly all reagents, however carefully purified, still contain, or extract from the vessels used, traces of impurities, which are eventually weighed in part with the constituents of the rock. The dust entering an analysis from first to last is very considerable, washings of precipitates may be incomplete, and if large filters are used for small precipitates the former may easily be insufficiently washed.

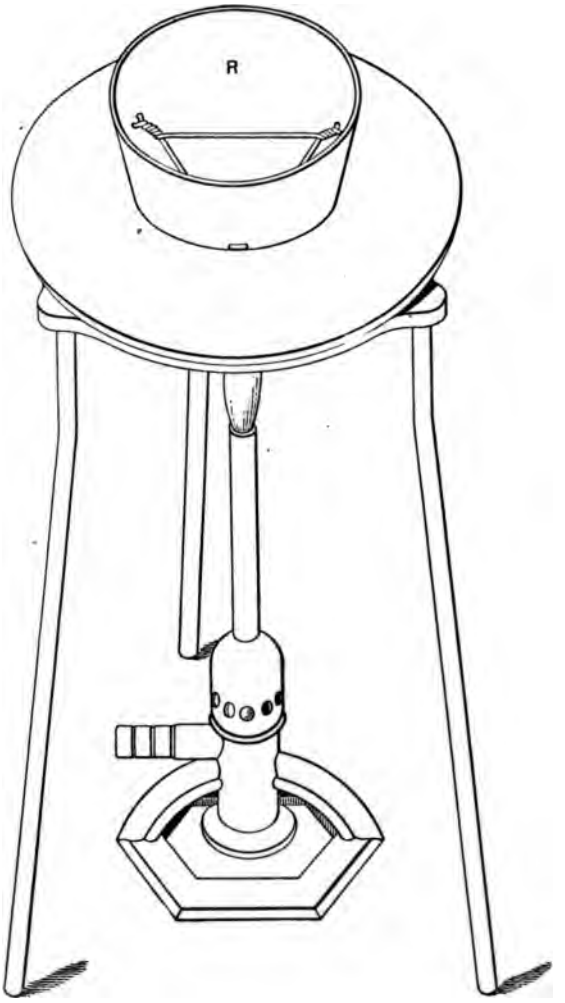

FIG. 2.—Radiator for rapid and safe evaporation. R is of sheet iron, also nickel (Jannasch). Various sizes. A convenient height is 7cm, width at top 7cm and at bottom 5cm.

Given the purest obtainable reagents, an ample supply of platinum, facilities for working, and a reasonably clean laboratory, there is no excuse for failure on the part of a competent chemist to reach a summation within the limits 99.75 and 100.50. Failure to attain 100 per cent in several of a series of analyses of similar nature should be the strongest evidence that something has been overlooked. Excess above 100.5 per cent should be good ground for repeating portions of the analysis in order to ascertain where the error lies, for it is not proper to assume that the excess is distributed over all determined constit-

uents. It is quite as likely, in fact more than likely, to affect a *single* determination and one which may be of importance in a critical study of the rock from the petrographic side.

VII. QUALITY OF REAGENTS.

It is due to say that all analyses performed in the Survey laboratories have been made with the purest reagents obtainable, either by purchase in the open market or by special preparation on the part of manufacturers or in the laboratory. The best acids made in this country are of a high grade and need no redistillation except for special experiments. Ammonia has always been redistilled at short intervals; and no sodium carbonate which exceeds 2½ milligrams of total impurity (see p. 50) in 20 grams (0.012 per cent) is used for the main portions, in which silica, alumina, etc., are to be estimated. For other portions, as phosphoric acid, fluorine, sulphur, a poorer grade is entirely allowable, provided it is free from the element to be determined, and from any other which might interfere with its estimation.

Hydrofluoric acid was always freshly distilled with potassium permanganate until the introduction of ceresine bottles afforded an article sufficiently pure for all but the most exacting work. Care must be exercised even yet, however, that no particles of paraffin or ceresine are floating on the acid, and that the latter is free from traces of chlorine whenever it is to be used for attacking silicates with a view to estimating chlorine (p. 103).

Potassium bisulphate has usually been prepared in the laboratory from sulphuric acid and potassium sulphate, since it is not always to be bought of satisfactory quality. Even then the normal sulphate had first to be examined, for it has been found to contain, on different occasions, notable amounts of lead, calcium, and silica.

The phosphorus salt used for precipitating magnesium has been found to contain iron, and calcium is almost always a constituent of ammonium oxalate. The latter has therefore to be purified or specially prepared, as also oxalic acid, ammonium chloride (in which latter manganese has been observed), and occasionally other reagents. Some hydrogen peroxide contains fluorine, which renders it unfit for use as a chemical reagent.

A "C. P." label is no guaranty whatever of the purity of a reagent; hence no chemicals should be taken on trust because of bearing such a label. Every new purchase should be examined, if it is one in which purity is a desideratum. In general all so-called "C. P." chemicals should at least stand the tests laid down by Krauch.[1]

Of late years the appearance upon the market of so-called guaranteed reagents promised to meet a long-felt want. But experience has

[1] Die Prüfung der chemischen Reagentien, 3d ed., Berlin, Julius Springer, 1896.

shown that with the pioneer in this line at least the guaranty amounts to nothing, the reagents being sometimes worse than the "C. P." articles emanating from sources which make no claim to special purity for their goods, and redress being unobtainable. The "guaranteed reagent" needs checking as much as any other.

VIII. PRELIMINARY QUALITATIVE ANALYSIS.

A complete qualitative analysis of a rock, preceding the quantitative examination, is in most cases a sheer waste of time. A few constituents may now and then be specially looked for, but in general time is saved by assuming the presence of most of them and proceeding on that assumption in the quantitative analysis.

PART II. METHODS.

I. INTRODUCTORY REMARKS.

The order hereinafter followed in describing the various chemical separations has little relation to the affinities of the constituents of the rock, but those are grouped together which can be conveniently determined in the same portion of rock powder. Thus, in the main portion are usually determined SiO_2, TiO_2, MnO, NiO, CaO, SrO, MgO, total iron, and the combined weight of all the following: Al_2O_3, TiO_2, P_2O_5, ZrO_2, all iron as Fe_2O_3, and nearly if not quite all vanadium as V_2O_5, also perhaps rare earths if present. In a separate portion is estimated FeO, and also the total iron, as well as BaO, if these last are desired as checks. The alkalies need a portion for themselves. In another, ZrO_2, BaO, and total sulphur are very conveniently determined. For V_2O_3 and Cr_2O_3 still another and usually much larger portion is to be used. Determinations of CO_2, C, H_2O, Fl, Cl, are all best made in separate portions of substance, though various combinations are possible, as CO_2 and H_2O, C and H_2O, or H_2O, Fl, and Cl. In fact, by a judicious selection and combination of methods a very satisfactory analysis can sometimes be made on 4 grams of material without omission of anything of importance, though the time consumed will be greater than if ample material is available.

As an illustration of the advantage to be gained by a little judgment in the combination of methods, the case of sulphur, barium, and zirconium may serve. Many chemists never look for the second and third of these, but by following the procedure given on pages 74–76 very little more labor is expended in confirming their presence or absence than that of sulphur alone.

With only occasional exceptions, nearly all the constituents mentioned on page 20 can be estimated if present in portions of powder not exceeding 1 gram each in weight.

This is a convenient weight to take for the main portion in which silica, alumina, etc., the alkaline earths, and magnesia are to be sought; but it should, in general, be a maximum, because if larger the precipitate of alumina, etc., is apt to be unwieldy. Its weight can not often be much reduced with safety if satisfactory determinations of manganese, nickel, and strontium are to be expected. For the alkali por-

tion one-half gram is a very convenient weight. In general, it may be made a rule not to use more than 2 grams for any portion which has to be fused with an alkali carbonate, as for sulphur, fluorine, and chlorine. For carbon dioxide the weight may rise to 5 grams, or even more, if the amount of this constituent is very small, without expenditure of any more time than is required by 1 gram, and with correspondingly greater approach to correctness in the result. For vanadium also a larger weight than 2 grams is usually demanded.

II. SPECIFIC GRAVITY.

BY SUSPENSION IN WATER.

Ordinary method.—This determination, when required, is best made upon one or several fragments weighing up to 20 grams. They are held together by a fine platinum wire ready for suspension from the balance, and thus held are placed in a small beaker to soak over night in distilled water under the exhausted receiver of an air pump, side by side with a similar beaker of water. Boiling is, of course, a much less effective means of removing air than the air pump, and the boiling water may exert an undesirable solvent and abrading effect. In the morning the wire is attached to the balance arm, the rock fragments remaining immersed in the water; a thermometer is placed in the companion beaker of water, now likewise in the balance case, and the weight is at once taken. Both vessels of water having precisely the same temperature, it is quite unnecessary to wait for the water to assume that of the balance should it not already possess it. The fragments are now lifted out, without touching the vessel, and carefully transferred to a tared crucible or dish; the wire is removed and at once reweighed, with the precaution that it dips just as far into the water now as when weighted. Hereby a special weighing of the wire out of water is avoided. The sample may now be dried on the water bath and then at 110° C. for some hours to certainly expel all absorbed water, and weighed after prolonged cooling in the desiccator. It is better to ascertain the weight of the dry rock after soaking in water than before, in order to avoid the error due to possible breaking off of a few grains between the two weighings. Should the density of the rock in air-dry condition be required, it may be left exposed to the air for a long period after drying and before weighing;[1] but the difference will only

[1] In view of the uncertainty as to what constitutes hygroscopic water (see p. 35), this course is perhaps more to be commended than the former, and seems imperative for certain zeolitic rocks. In such cases it is best to weigh the fragments before putting to soak, and afterwards to collect on a Gooch crucible the grains which may have fallen off in the water. Should no crucible of this kind be available, a paper filter may unhesitatingly be used and incinerated with the powder, owing to the small amount of which the error due to loss of even all its water during ignition is quite negligible.

in exceptional cases affect the second decimal by more than a single unit. For instance, an undried rock of 2.775 specific gravity containing in the uncrushed state the high percentage of 0.3 hygroscopic moisture will have a density of 2.79 when dry; a rock of 2.982 specific gravity, undried, will have a density of 3.00 after removal of 0.3 per cent of moisture. The difference becomes greater as the density of the rock increases.

This method of ascertaining the specific gravity of rocks is certainly more convenient than, and for compact rocks is believed to be decidedly preferable to, that of the pycnometer, in which the fragments must be reduced to small size with consequent formation of more or less powder, which is subject to slight loss in the various manipulations. To exclude this powder and employ only small fragments would introduce a possible source of error, since it is likely to consist largely of the most easily abraded minerals and consequently not to have the average composition of the mass. By following the instructions given above, loss of material is absolutely avoided, a decided saving in time is effected, and considerable weights can be easily employed with consequent lower probable error in the results. To vesicular rocks, however, notably certain lavas, the above procedure is, of course, inapplicable, unless the datum is desired for certain considerations in which the relative density of large rock masses as they occur in nature is sought, as for the comparison of building stones or the calculation of large known or assumed areas of particular rocks.

Penfield's method for mineral fragments.—Penfield[1] recommends the following modification of the suspension method as more convenient than that by the pycnometer in many cases for small fragments of minerals.

After boiling in water, the substance is transferred with water to a small glass tube about 8 mm. by 35 mm., provided with a fine platinum wire for suspension. This is weighed full of water in another vessel of water, and again after the removal of the mineral, the weight of which is found after drying.

This method is, of course, more applicable to homogeneous minerals than to rock fragments, and will therefore be applied in rock analysis chiefly to the determination of the specific gravity of the mineral grains separated by heavy solutions or acids.

PYCNOMETER METHOD.

If the pycnometer has to be used, as is generally the case when the density of any one of the mineral ingredients of a rock is desired after

[1] Am. Jour. Sci., 3d series, Vol. L, p. 448, 1895.

separation by one of the approved methods, it being then in a more or less finely divided state, the most accurate procedure is that adopted in this laboratory by Mr. L. G. Eakins a number of years ago. The pycnometer used is one with a capillary stopper, provided with a millimeter scale etched in the glass, the divisions being numbered both ways from the center and calibrated by mercury so that the value of each one in weight of water is known. The capacity of the flask filled with water to the zero division is then calculated for every half degree of temperature from 0° C. to 30° C., by making a series of careful weighings, in which, the capacity of the stem being known, it is quite immaterial at what level the water stands provided it is within the limits of the scale. The exact temperature is obtained by an accurate thermometer placed in a companion vessel of similar shape to the pycnometer and containing a like amount of water, both being left in the balance case till its temperature has been nearly or quite assumed, as shown by a second thermometer. The weighing must of course be made before the thread of water has sunk beneath the lowest division, which it will do after a time, even though at first filling the bore to the top of the stopper; and the corrected weight full of water to the zero mark is found by adding or subtracting the needed amount, as shown by the height of the thread on the scale.

For each pycnometer in use, and these are of different sizes, is prepared a table showing its weight, the value of each scale division in grams of water, and the capacity of the flask at different temperatures, as indicated above. The preparation of such a series of flasks is time saved in the end, for the weighing of the flask full of water each time a density determination is made is rendered superfluous. All that is necessary is to look up in the table the weight corresponding to the temperature.

The density of the previously weighed substance in this case is now determined in much the same way, after the unstoppered pycnometer containing it and nearly filled with water has stood with its companion vessel of water under the air pump the necessary length of time. The water needed to fill the flask is taken from its companion.

All who have used the pycnometer method for fine substances know the difficulty experienced in preventing a portion from being held at the surface, despite all attempts at making it sink. Hence it often happens that a very small portion runs out around the sides of the stopper on inserting it. If the flask rests in a small tared dish the grains thus forced out may be washed down into it and weighed after evaporation in order to get the correct weight of that in the flask; or, after weighing, the contents of the flask may be emptied into a tared dish and the water slowly evaporated off in order to get the weight *of the mineral.* Usually this way is less to be recommended than the *other.*

HEAVY SOLUTIONS NOT SUITABLE FOR ROCKS.

Because of their roughness, porosity, and complex mineral composition the density of rock fragments can not be accurately determined by that of heavy solutions in which they may remain suspended.

III. PREPARATION OF SAMPLE FOR ANALYSIS.

QUANTITY OF ROCK TO BE CRUSHED.

In the great majority of cases a few chips from a hand specimen will well represent the average of the mass, but with rocks in which a porphyritic structure is strongly developed the case is different. Here a large sample should be provided, gauged according to the size of the crystals, and the whole of this should be crushed and quartered down for the final sample. Unless this is done, it is manifest that the analysis may represent anything but the true average composition of the rock.

CRUSHING.

Mechanical appliances for reducing samples to fine powder are much in use in technical laboratories, where they answer their purpose more or less satisfactorily, and something similar is needed in those scientific laboratories where rock analysis is of daily occurrence and many samples must be reduced to fine powder in a short space of time. For accurate analyses the use of steel crushers and mortars is out of the question, because of the danger of contamination by particles of metal and the impossibility of cleansing the roughened surfaces after they have been in use a short time. Extraction by the aid of a magnet of steel particles thus introduced into the powder is quite inadmissible, since the rocks themselves, almost without exception, contain magnetic minerals. The method of rough crushing on a small scale found to be most satisfactory in practice is to place each fragment as received on a hard steel plate about 4½ cm. thick and 10 cm. square, on which is likewise placed a steel ring 2 cm. high and of about 6 cm. inner diameter, to prevent undue flying of fragments when broken by a hardened hammer. In this way a considerable sample can soon be sufficiently reduced for transfer to the agate grinding mortar with a minimum of metallic contamination.

For breaking large pieces of rock to small sizes a thick iron plate with specially hardened surface and a similarly hardened pounder, such as street pavers use, will probably render the best service, but the hardening must be done with extreme care.

GRINDING.

Of the various grinding arrangements on the market purporting to *fulfill their purpose* few, if any, observed have met the conditions

required by the work in hand. Either the mechanical arrangement is complicated or cumbersome, requiring more power or space than is usually at disposal or causing too much noise, or thorough cleansing is difficult and troublesome, or there is likelihood of contamination from oil or grease or lack of facility for the removal of all powder from the mortar. These last defects are especially prominent in those forms in which the mortar is fixed in its setting.

All rock samples have therefore been reduced to powder by hand, involving a great expenditure of time and labor. Ordinarily an extremely fine state of division is unnecessary, except in the case of those portions in which alkalies and ferrous iron are to be estimated or where soluble constituents are to be removed by acids, etc., and in such cases the final grinding can be done at the balance table on a small portion slightly in excess of the quantity to be weighed off.

The process of sifting through fine cloth, the German "Beuteln," is not one always to be commended, because of the time required and, more especially, because of the certainty of contamination by cloth fiber, which in the ferrous-iron portion might affect the result. Still less should metal sieves be used.

WEIGHT OF GROUND SAMPLE.

The sample when ground should weigh not less than 10 grams, and preferably 20 in case it should be necessary to repeat or advisable to employ unusually large portions for certain determinations, notably carbonic acid. Rock analysis has in this respect an advantage over mineral analysis, since material is almost always available in ample quantity and any desired number of separate portions may be used, whereas with a mineral the analyst is frequently compelled to determine many or all constituents in a single, often very small, portion of the powder. This course often involves delay and the employment of more complicated methods of separation than are usually necessary in rock analysis.

IV. WATER—HYGROSCOPIC, ZEOLITIC, CRYSTAL.

Importance of employing air-dry powder for analysis.—The time-honored custom of drying a powdered specimen before bottling and weighing has long seemed to the writer one that has no sound basis in reason. Its object is of course plain, namely, that of securing a uniform hygroscopic condition as a basis for convenient comparison of analytical results, since some rocks contain more hygroscopic moisture than others. Nothing, however, is more certain than that by the time the substance is weighed it has reabsorbed a certain amount of moisture, *small, indeed,* in most cases, but very appreciable in others; and

further, with every opening of the tube moisture-laden air enters and is inclosed with the remainder of the dry powder. It therefore may very well happen that a powder at first dry will, after several openings of the tube, especially at considerable intervals, be nearly as moist as when first inclosed.

It is preferable to weigh the air-dry powder and to make a special determination of moisture. If all the portions necessary for an analysis are weighed out one after another, or even at different times on the same day, the error due to difference of hygroscopicity in dry and moist weather, which for most of the separate portions is an entirely negligible quantity, is eliminated. Only in the main portion, in which silica and the majority of the bases are to be estimated, can it ever be an appreciable factor.

Temperature of drying.—As to the temperature to be adopted for drying in order to determine so-called hygroscopic moisture, the practice has varied at different times and with different workers, ranging from 100° to 110° C. For the great majority of rock specimens it is quite immaterial which of these temperatures is adopted, since no greater loss is experienced at the higher than at the lower temperature, given a sufficient time for the latter. It is the present practice in this laboratory to employ a toluene bath giving a temperature of about 105° C. Should the results show a very unusually high loss, the powder is reheated at, say, 125°, in order to learn if the loss is progressive with increased temperature. In the affirmative case it may be well to repeat the drying at 100°, for a portion of the loss at 105° was probably due to combined water from a mineral or minerals in the rock; but in that case even the loss at 100° may sometimes very well include combined water, in which case drying over sulphuric acid alone may be desirable, or over dry sand.

Cautionary hints.—In this latter connection it is proper to point out certain pitfalls in the path of the unwary, which, however, are far more likely to be encountered in the analysis of minerals, where their influence may be of far-reaching consequence.

A mineral which loses a great deal of water over sulphuric acid—2 or 3 per cent, for instance—may need an exposure of several days or even weeks for its complete extraction. If the weighings are made from day to day, the apparent limit may be reached long before all water really removable has been taken up by the acid. Whenever the crucible, after weighing, is replaced in the desiccator it is no longer in a dry but a more or less moist atmosphere, and its contents, even when covered, sometimes absorb a part of this moisture and retain it so persistently that the acid is unable to bring the powder beyond its previous state of dryness in the next twenty-four hours. In fact, it may be unable even to reach it unless greater time is allowed. An experiment

on 1 gram of tyrolite, made and published some years ago, seems to illustrate this point in part:

Hours exposed.	Loss.	Hours exposed.	Loss.
	Gram.		*Gram.*
18	0.0231	24	0.0002
26	.0083	24	.0003
23	.0029	48	.0006
24	.0012	24	.0002
23	.0008	283	.0380
24	.0001		
25	.0003		

The experiment might reasonably have been considered ended after the one hundred and fifty-eighth hour, when a loss of but 0.1 milligram was shown during twenty-four hours; but nevertheless a nearly steady loss of 0.3 milligram per day took place for six days more, and might have been longer observed but for the interruption of the experiment.

Again, it is a common practice to determine the water given off by hydrous minerals in an air bath at temperatures far above 100° C. To insure accuracy this experiment should not be made in crucibles or dishes which must be cooled in a desiccator. One instance will suffice: A gram of a mineral mixture containing about 17 per cent of water, of which about 3 per cent was driven off at 100° and 8 or 9 per cent at 280°, was, after several hours' heating at the latter temperature, placed in a desiccator over sulphuric acid and weighed as soon as cold, then replaced and again weighed the next day. It had regained 1½ per cent of its original weight, although the desiccator was tightly closed and the crucible covered, showing apparently a drying power superior to that of the acid.

A specimen of tyrolite was found on one occasion to lose 10.34 per cent at 280° C., and on another occasion 14.33 per cent. In the latter case the drying and heating at progressive temperatures had continued during a period of 528 hours, the weighings being made usually from day to day; whereas in the former the duration of the experiment was much shorter and the intervals between weighings were but a few hours each.

Procedure in special cases.—For experiments of the kind just indicated the powder should be heated in a weighed tube, through which a current of dry air can be passed, and allowed to cool therein, or else the water given off should be collected and directly weighed in *suitable absorption* tubes, even though the long time often required *is an objection to* this lattter method, since the absorption tube may

gain weight, other than that of the water from the mineral, sufficient to introduce an appreciable error.

The recent important research of Friedel[1] well shows what errors are possible in the determination of this easily removable water, since he found that certain zeolites which had been largely dehydrated but not heated to the point of rupture of the molecular net, could then absorb, instead of water, various dry gases in which they might be placed, as carbon dioxide, ammonia, carbon disulphide, and others, even air in large quantities, and certain liquids. In the light of this observation the cause of the great increase of 1½ per cent in weight of the partially dehydrated mineral mentioned on p. 34 may very possibly be attributed to air from the desiccator instead of moisture, as was at the time supposed. At any rate, as Friedel says, the danger of accepting a loss in weight as an index of the amount of water lost is clearly shown, and thus that method of determining water is for many cases fully discredited. Just what method to adopt must be largely left to the judgment of the operator, who will often be guided by the mineral composition of the rock as revealed by the unaided eye or the microscope.

Friedel (loc. cit.) indicates a means for determining the true weight of water lost by minerals behaving like the zeolites, even without collecting the water lost, namely, by driving out of the dehydrated and weighed mineral, under proper precautions, any air it may have absorbed in the process of drying and cooling, and collecting and measuring this air and thus finding its weight, which, added to the apparent loss, gives the true contents in water.

Argument in favor of including hygroscopic water in summation.—The question has been asked: "If the so-called hygroscopic water is not always such, but not infrequently includes combined water, why is not its determination and separate entry in the analysis entirely unnecessary? Why make a distinction, which, after all, may not be a true one?" The question involves the further consideration of the advisability of including in the analysis at all the loss at 100° or 110° C. Many petrographers desire to have all analyses referred to a moisture-free basis, in order that they shall be strictly comparable, and therefore would omit the "hygroscopic" water from the list of constituents. This would be eminently proper were it always possible to be sure that the loss at 100° truly represents mechanically held water. Since it very often represents more, and the determination as to whether or not it does in each case is not always possible, and would add to the time required for the analysis, it seems necessary to include this water. What errors may arise from its exclusion the following rather extreme case well illustrates: Certain rocks of Wyoming in powder form lost from 1 to 2 per cent of moisture at 110°. That not even an appreciable fraction of this was truly hygroscopic the fact of

[1] *Bull. Soc. Min.*, Vol. XIX, pp. 14, 94, 1896; Comptes Rendus, Vol. CXXII, p. 1006, 1896.

the uncrushed rocks losing the same amount fully demonstrates; yet the rule followed by many chemists and petrographers would have involved the removal of all this water as a preliminary to beginning the analysis, and not only would a most important characteristic have passed unnoticed, but the analyst would have reported an incorrect analysis, inviting to false conclusions and possibly serious confusion.

Separate entry of hygroscopic and combined water.—To revert now to the primary question, it may be said that the estimation of the loss at 100° or 110° C. and its separate entry in the analysis is advisable as not infrequently affording at once to the lithologist an indication of the mineral character of one or more of the rock constituents, thus perhaps confirming the microscopical evidence or suggesting further examination in that line. An unusually high loss at 100° would be regarded as probable evidence of the presence of zeolites or other minerals carrying loosely combined water. It has been objected that the true hygroscopic moisture varies with the degree of comminution of the sample and with the condition of the air at the time of weighing, and that it is therefore improper to incorporate it in the analysis; but this variation is ordinarily not at all great. Perhaps the time may come when it will be the rule to ascertain by additional heating at a higher temperature whether the water lost at 100° is to be regarded as purely hygroscopic. In such case it would be proper to omit it, and a distinct advance would undoubtedly be scored.

Is all true hygroscopic water expelled at 100°?—It has been tacitly assumed in the foregoing that true hygroscopic water can all be expelled at 100°, which perhaps is not to be accepted as universally true. Eminent authority holds that it is impossible, in the cases of certain foliaceous minerals, notably the micas, to thus entirely remove it, but that a part is only driven off at higher temperatures. If this is true a further uncertainty is introduced in its determination, which not only strengthens the argument in favor of entering all water in the tabulation, but also serves to emphasize the difficulties of the situation.

APPARATUS FOR THE DIRECT DETERMINATION OF WATER AT DIFFERENT TEMPERATURES.

A form of drying oven devised by Dr. T. M. Chatard[1] is in use in this laboratory for determining water at different temperatures up to 350° C., and gives entire satisfaction. It is an asbestos-covered copper box B, shown in different aspects and parts in the accompanying fig. 3. The box is so constructed that the tube with its contents can be removed without detaching from either the drying or collecting tubes, which is a great advantage if it is desired to afterwards apply the direct

[1] *Am. Chem. Jour.*, Vol. XIII, p. 110, 1891; Bull. U. S. Geol. Survey No. 78, p. 84.

heat of a lamp in order to expel the water retained at 300° to 350° C. To facilitate this removal the stand is on rollers, so that after clamping the projecting end of the tube and removing the front of the box F and the little side pieces S closing the horizontal slits, the oven can be rolled bodily backward, leaving the tube and its attachments in their original position, ready for further heating over a burner or blast. The removable front F of the oven is made of two pieces of sheet asbestos board stiffened by an interlaid piece of sheet copper. The inner piece of asbestos board fits snugly into the box, while the

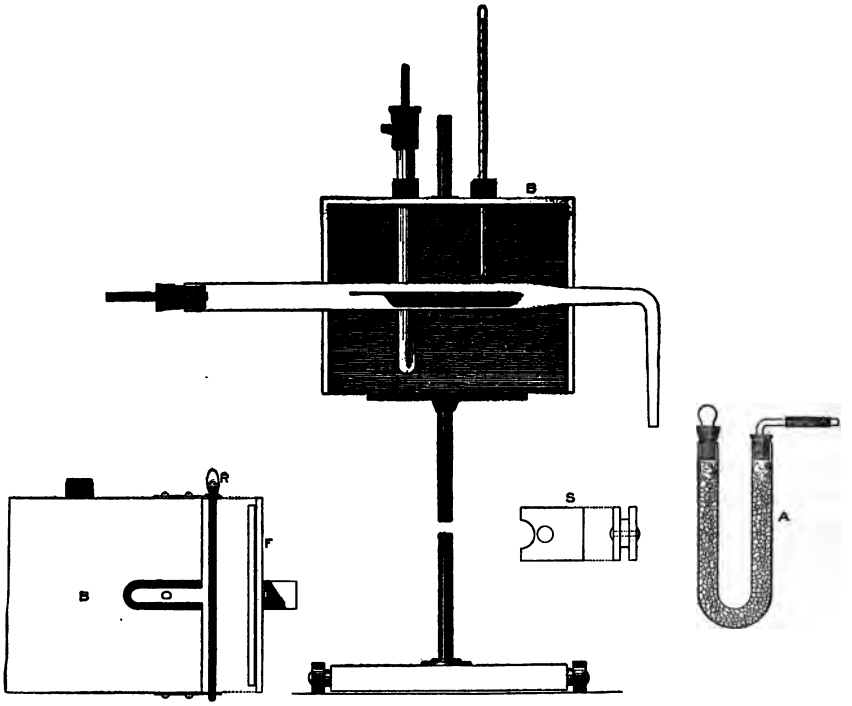

FIG. 3.—Chatard's form of drying oven for water determinations. B, copper box, 18cm. long, 10½cm. high, 9cm. wide, open in front, its sides and top covered with asbestos board; S, two slides of different sizes to close the openings O, after the tube is in position; F, asbestos-board front stiffened by an interlaid sheet of copper; R, metal rod to hold front in place; A, calcium chloride absorption tube.

outer one, being slightly larger, by its projecting edges hinders the door from falling in and helps to prevent air currents. This door is held in place by the metal rod R. The little slides S are made in a somewhat similar manner, and are intended to slip in from the front and close the two openings O after the tube is in place, but before closing the front.

For other forms of tubes adapted to similar determinations, see pages 40 and 46.

V. WATER—TOTAL OR COMBINED.

ARGUMENTS AGAINST "LOSS ON IGNITION" METHOD.

In a few cases the simple loss on ignition of a rock will give the total water with accuracy, but in the great majority there are so many possible sources of error that this old-time method can rarely be used with safety. Only when the rock is free from fluorine, chlorine, sulphur, carbon, carbon dioxide, and fixed oxidizable constituents can the loss be accepted as the true index of the amount of water present, and it is rarely that a rock is met with fulfilling these conditions, especially as to the absence of ferrous iron. Blast ignition in presence of carbon dioxide alone of the above list may give a correct result, after separate estimation of the carbon dioxide, provided this emanates from carbonates of the earths and not from those of iron or manganese. The long-maintained and still upheld idea that in presence of ferrous iron a sufficiently correct result is obtainable by adding to the observed loss an amount needed for oxidizing all ferrous iron is not justifiable. There can be no certainty that the oxidation has been complete, especially in the case of readily fusible rocks, and at the high temperature of the blast a partial *reduction* of higher oxides is not only possible but sometimes certain. The inability to insure complete oxidation by simple ignition is illustrated in the case of precipitated ferric hydroxide which has been ignited in contact with its filter paper. If the quantity was in any degree large it is sometimes decidedly magnetic, presumably from presence of magnetic oxide, which no amount of heating wholly oxidizes, especially in the larger grains. Neither is evaporation with nitric acid and reignition sufficient to destroy the magnetic property of the oxide, as has been claimed.

Direct weighing of the water evolved is then imperative in most cases, and of the numerous methods advocated, or in general use, several will now be considered.

DIRECT WEIGHING OF THE WATER WITHOUT THE USE OF ABSORPTION TUBES—PENFIELD'S METHODS.

For minerals easily deprived of their water.—If no other volatile constituents than water are present, the beautifully simple method first used by Prof. G. J. Brush and extended by Prof. S. L. Penfield[1] leaves nothing to be desired for accuracy. It consists simply in heating the powder in a narrow tube of hard glass, enlarged at the closed end and provided with one or two further enlargements in the middle to hold the water and prevent its running back and cracking the hot glass. A capillary glass stopper fitted in with rubber tubing pre-

[1] Am. Jour. Sci., 3d series, Vol. XLVIII, p. 31, 1894; Zeitsch. für anorg. Chemie, Vol. VII, p. 22, 1894.

vents loss of water by circulating air currents. *The tube being held* horizontally, the bulb is heated to any required degree by the Bunsen or blast flame. Moistened filter paper or cloth wound about the cooler parts of the tube insures condensation of all water. The heated end being finally pulled off, the tube is weighed after cooling and external cleansing, and again after the water has been removed by aspiration. For most rocks, as they contain little water, central enlargements of the tube are hardly needed.

Various forms of tubes used by Penfield are shown in fig. 4.

Before using, even if apparently dry, "these tubes must be thoroughly dried inside, which is best accomplished by heating and aspirating a current of air through them by means of a glass tube reaching to the bottom."

How this simple tube is made to afford entirely satisfactory results

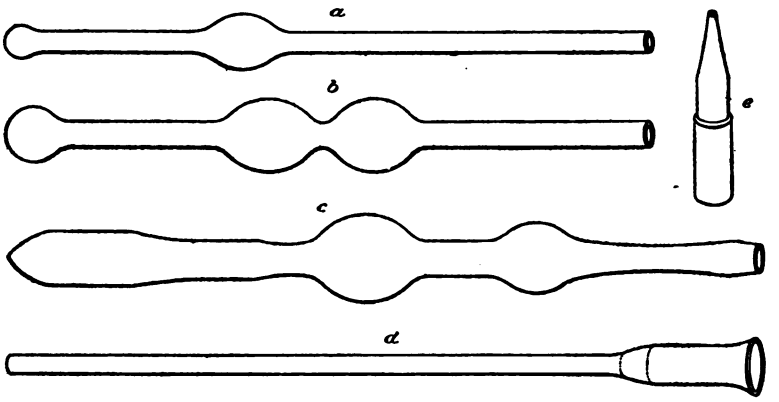

FIG. 4.—Penfield's tubes for water determination in minerals. *a*, *b*, *c*, different forms of tubes; *d*, thistle tube for introducing the powder; *e*, capillary-tipped stopper.

with minerals, even when carbonates are present, is fully set forth in the paper cited.

Few rocks, comparatively, are altogether free from other volatile constituents. Hence, for refined work the application of this apparatus in the simple manner above set forth is limited. It may, however, be used with the addition of a retainer for fluorine, sulphur, etc., in the shape of calcium, lead, or bismuth oxides.

For minerals not easily deprived of their water.—When minerals are present which do not give up their water wholly, even over the blast, as talc, topaz, chondrodite, staurolite, etc., Penfield's simple combination of fire-brick and charcoal oven, depicted in fig. 5, must be used, either with or without a retainer for fluorine, as circumstances demand. The part of the tube in the fire is to be protected by a cylinder of platinum foil tightly sprung about its end, and the part outside by asbestos board, as well as by wet cloth or paper. A piece of charcoal

is likewise laid on the tube, as well as beneath and behind, and the blast flame is given a horizontal direction, so as to play upon the side of the apparatus. In this way a most intense temperature can be reached.

In whichever way the apparatus may be used, the water found is

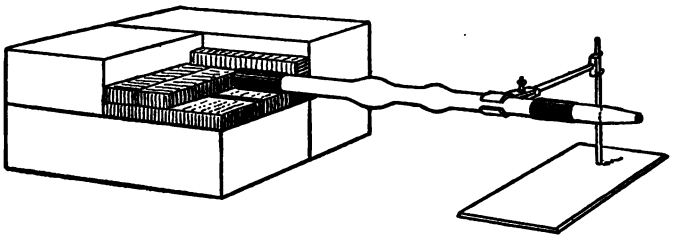

FIG. 5.—Penfield's fire-brick and charcoal oven for use in determining water.

the total water, from which that found separately at 105° C. may be deducted if desired.

DIRECT WEIGHING OF THE WATER IN ABSORPTION TUBES.

Penfield's procedure.—The simplest of these methods as to apparatus, and one permitting, by the use of auxiliary arrangements such as are shown and described on page 37, the determination of the hygroscopic as well as any other fraction of the water, is the following glass-tube arrangement (fig. 6) of Dr. Penfield's,[1] whereby the brick and charcoal oven already referred to (fig. 5) comes again into play, but without the half brick shown in that figure.

The tube is of about 15 mm. internal diameter, and is fitted with two platinum cylinders at A, one inside, the other outside, where the heat exposure is to be most intense.

These are made from pieces of platinum foil, about 0.07 mm. in thickness and 8 by 11 cm. in diameter, which have been previously bent around glass tubes of such

FIG. 6.—Tube for water determination according to Penfield. A, outer protecting covering of platinum foil. A second similar foil on the inside prevents the glass from collapsing when heated to softness. *b*, cross section of platinum boat.

a size that when applied to the combustion tubing the spring of the metal will hold them in place. A large platinum boat, 7 to 8 cm. long and 11 to 12 mm. in diameter, with a cross-section like *b*, should be used, since this will readily hold a gram of mineral mixed with 5 grams of sodium carbonate. * * * The tube is placed in the angle formed by the charcoal lining, some pieces of charcoal are placed at the sides in front, leaving an opening through which the flame may be directed, and an additional piece is laid on top. The tube can readily be brought to a full white heat,

[1] Am. Jour. Sci., 3d series, Vol. XLVIII, p. 37, 1894; Zeitsch. für anorg. Chemie, Vol. VI, p. 22, 1894.

and by forcing a slow current of dry air through the apparatus the carbon dioxide resulting from the decomposition can be removed and the water carried over into the weighed absorption tube. The glass fuses between the platinum casings, and in a number of experiments that have been tried there has not been a single instance where the glass tube has broken or shown any indication of breaking. After heating the tube will not crack if it is left to cool slowly on the charcoal, but it cannot be used a second time. * * * At the high temperature to which the glass is subjected it of course becomes very soft and the ends must be properly supported; also the rubber connections and absorption apparatus must be carefully screened by asbestos board. By constructing a cover for the boat no material need be lost by spattering, and after making the water determination the contents may be used for the remainder of the analysis.

The inner cylinder of platinum serves to prevent the glass from collapsing as it softens, whereby distortion of the boat would result and its withdrawal for further examination of its contents would be impossible.

Gooch's apparatus.—Of more elaborate apparatus, designed to be used with fluxes, the tubulated platinum crucible invented by Dr. Gooch[1] is capable of affording most excellent service, and it is the one by which far the larger number of water determinations in this laboratory have been made.

Fig. 7, which hardly needs detailed description, shows it in a modified form, which differs from the original forms of Gooch in that the tubes for connecting with both the drying and absorption vessels are constructed wholly of platinum instead of lead glass, the vertical one being bent horizontally at right angles for convenient attachment to the drying towers, and the side one also bent at right angles, but downward, and having its end slightly drawn in at E (fig. 7) so as to admit of easy insertion in the rubber stopper of a U-shaped calcium-chloride tube as shown in fig. 9 (p. 44). With tubes of the lengths shown in the figure there is absolutely no danger of their ends becoming hot enough by conduction to scorch or soften the rubber stopper or other connection.

The extra first cost of the platinum extension to these tubes over the lead-glass ends of Gooch's original and modified forms need hardly enter as a factor into the question of employment of this apparatus. The glass ends often break, and only a rich lead glass, not easily obtainable, can be used, since it alone will not crack at the joint with the platinum after cooling. In its present form the whole apparatus weighs approximately 88 grams.

As an adjunct to its convenient use there is needed an ordinary upright iron ring-stand, with two small sliding rings, and a sliding ring-burner provided with entering ducts for gas and air blast. Across the uppermost ring there is an arrangement of stout platinum wire (S, fig. 8), forming at the center of the ring a secure seat for the

[1] Am. Chem. Jour., Vol. II, p. 247, 1880; Chemical News, Vol. XLII, p. 326, 1880.

upturned flange of the crucible proper. Both rings and burner can be clamped firmly at any height.

The rock powder, having been placed in the cylindrical crucible (C, fig. 7), is there mixed with not more than 3 or 4 grams of fully dehydrated sodium carbonate,[1] or more of lead chromate if carbon is to be likewise determined. The crucible is sunk in its seat S (fig. 8) in the upper ring R′ and the tubulated cap T (fig. 7) is fitted on and attached to the calcium chloride drying towers—preceded by one containing potassium hydroxide if carbon dioxide is likewise to be estimated—on

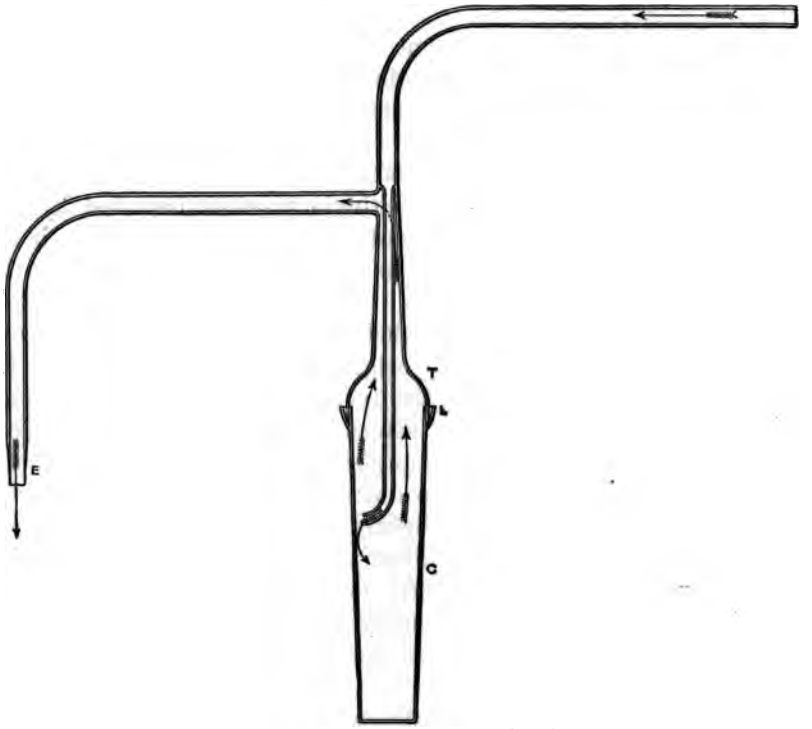

FIG. 7.—Modified form of the Gooch tubulated platinum crucible for the determination of water, one-half natural size. Weight about 88 grams.

the one side, and to a sulphuric-acid bulb tube B (fig. 9) on the other. Powdered sodium tungstate—free from arsenic, which would soon ruin the crucible lips—is now poured into the flanged lip L (fig. 7) in which the cap rests, and a metal vessel of cold water having been raised up by the lower ring R″ (figs. 8 and 9) until the platinum crucible is sufficiently immersed, the flame of an ordinary blast lamp is turned on to melt the tungstate. As soon as this is fused the flame is removed

[1] This has been heated for a length of time to near its fusing point over a free flame or in an air bath, to decompose the bicarbonate it usually contains, and then placed in a desiccator. Thus heated *it is not very hygroscopic.* Penfield found that 2.5 grams of it, spread out on a watch glass, gained *only .0002 gram in 15 minutes.* Potassium carbonate and potassium-sodium carbonate are too hygroscopic *by far to be available.*

and the salt solidifies and makes an air-tight joint, the test of which is the permanence of the column of sulphuric acid in the bulb tubes caused by the contraction of the air in the platinum apparatus as it cools.

After drying by a current of air at 105° C. for two hours, more or

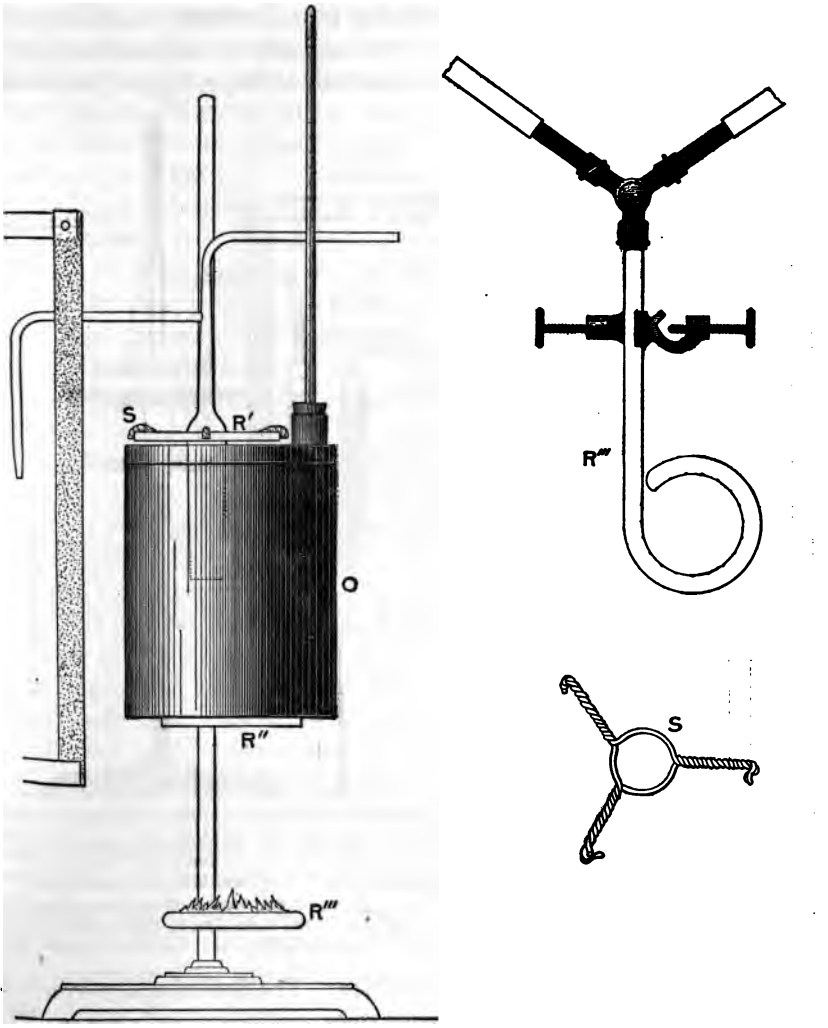

FIG. 8.—Details of the Gooch crucible for determining water. S, seat of stout platinum wire resting on ring R', and serving as a support for the crucible; R''', blast-fed ring burner; R'', support for air or toluene bath O.

less (see below, p. 45), by means of an air or toluene bath as shown in figure 8, the absorption tube A (fig. 9) is interposed between the sulphuric-acid bulbs and the apparatus, being fitted to the latter by its *stopper, which is at other* times closed by a glass plug, and while a slow

current of air continues to pass the gradual heating and subsequent fusion of the flux is brought about by the blast-fed sliding ring-burner R‴ (figs. 8 and 9). The sodium-tungstate joint is shielded from the flame by small pieces of asbestos board P (fig. 9), cut out so as to fit the crucible. When fusion is complete, as shown in the case of sodium-carbonate flux by the decided slackening of the gas current through the safety bulbs attached to the drying tube, the flame is extinguished and a current of air is allowed to continue until the apparatus is cold.

This apparatus suffers from the drawback of being slightly permeable

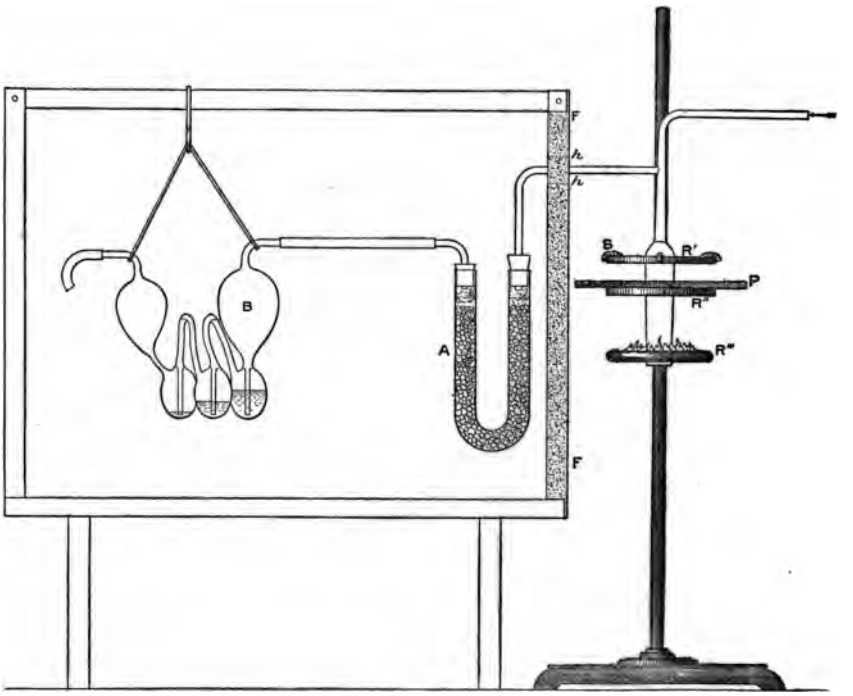

FIG. 9.—Arrangement during fusion of Gooch apparatus for determining water. R‴, blast-fed ring burner; P, protective asbestos-board shield resting on ring R″; FF, board forming end of frame and covered with asbestos board to prevent being set on fire by the heat of the blast. This serves at the same time as an efficient shield for the absorption-tube A. In it there is bored a round hole at *hh*, through which passes the outlet tube from the crucible. B, sulphuric-acid bulbs serving to show the rate of gas current through the absorption-tube and at the same time to prevent back entry of moisture from the air into A.

to combustion gases at high temperature. The defect can be overcome by causing the flame to play upon an outer ordinary platinum crucible, kept permanently filled with sodium-potassium carbonate. This protective crucible, however, is soon ruined for other purposes, being distorted by the alternate expansion and contraction of the carbonate.

It has been found that if the operation is carried out expeditiously and the final full heat applied for but a few minutes the error due to penetrating water gases is inappreciable. This hastening may be ren*dered safer by* using rather finely powdered calcium chloride in the

central section of the U-shaped absorption tube to avoid large air channels. Through this, or any apparatus based on similar principles, the air current should always be forced, not drawn. A warm blast directed upon the exit tube near its entrance into the absorption tube greatly shortens the time required and is to be recommended.

In this apparatus only the water expelled above 100° to 110° should as a rule be determined, and to effect drying of the mixed mineral powder and sodium carbonate, after luting the tubulated cap on the cylindrical crucible with sodium tungstate, the tube is sunk through a round hole in the cover into a small cylindrical air bath (fig. 8), which can be heated from beneath by the same ring burner which is subsequently to fuse the flux. A slow current of air is then forced through and the drying satisfactorily accomplished.

The reason why it is unsafe to attempt estimation of "hygroscopic" moisture in this apparatus is, that the luting of the two parts must be done by direct application of a flame to the tungstate, and considerable water vapor may enter the apparatus and be in part retained by the dried sodium carbonate.

Chatard's apparatus.—The platinum apparatus devised by Dr. Chatard[1] overcomes the permeability of the metal to gases and affords sharp results, moreover permitting of determining by direct absorption not only the hygroscopic water, but that which may be driven off at any desired temperature, either with or without fluxes. It is, however, perhaps even more costly than the Gooch apparatus, and the supposed nonliability to injury by warping, because of the protective layer of borax and asbestus, can hardly be considered as proved.

Merits of the above three forms of apparatus.—All of these apparatus, except the glass tube of the modified Brush method, permit of the estimation of other constituents besides water in the same portion if necessary, and by the use of lead chromate or potassium chromate, instead of sodium carbonate, graphite, or the carbon of organic matter, can be simultaneously determined with the water.

To one accustomed to its use, and with a drying and suspension attachment permanently set up, the Gooch apparatus, considering its limitations above set forth, offers perhaps the most handy and convenient means for the determination of water in rocks. Its high first cost, in comparison with the glass tube, is fully made up in time by its durability.

Jannasch's methods.—This zealous deviser of methods for mineral analysis has published in the Zeitschrift für anorganische Chemie and the Berichte der deutschen chemischen Gesellschaft several papers dealing with the problem of water determination in minerals, and in his text-book[2] these are collected in more or less modified form.

[1] Am. Chem. Jour., Vol. XIII, p. 110, 1891; Bull. U. S. Geol. Survey No. 78, p. 84, 1891.

[2] Praktischer Leitfaden der Gewichtsanalyse. Leipzig, von Veit & Co., 1897.

For the majority of silicates he finds dehydrated borax powder a most efficacious flux, usually at a very moderate temperature. The fusion is accomplished either in a platinum boat within a glass tube or in a tube of the form and dimensions shown in the accompanying fig. 10.

For rocks or minerals containing not much fluorine a retaining layer of granular lead chromate, or of previously fused and powdered lead oxide, is used as shown at *a*. Plugs of glass wool are used at *c*, *c*. Whether or not the boat is employed the borax is first introduced

FIG. 10.—Glass tube for determination of water (Jannasch). *b*, mixture of mineral powder with borax; *c*, *c*, plugs of glass wool; *a*, layer of lead chromate or lead oxide. Total length of the tube, 33 cm.; inside diameter, 12–14 mm.

and, together with the retainer, is thoroughly dried out in an asbestos oven by a hot-air current. Then, after cooling, the mineral powder is added and thoroughly mixed with the borax. Heat is applied by a flat flame to the mixture, which soon melts and forms a clear fusion, when the action is complete. The blast may be used in extreme cases. The layer of retainer must be kept warm by an auxiliary flame, and the absorption tube must be removed before the flame under the fused mass is extinguished, for the glass breaks as soon as this is done. Carbon dioxide can simultaneously be determined by attaching a soda-

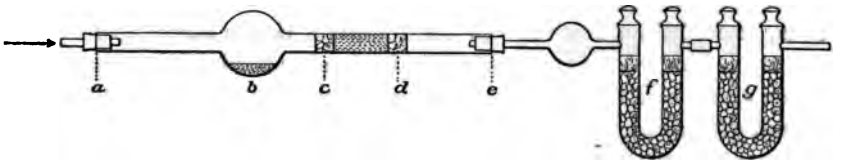

FIG. 11.—Glass tube for determination of water in special cases (Jannasch). Length from *a* to *e*, 26 cm.; inside diameter somewhat over 1 cm.; volume of bulb *b*, 25 cm³. *c d*, retaining layer of lead oxide between plugs of glass wool; *f*, calcium chloride absorption tube; *g*, protective tube.

lime tube to the calcium-chloride tube. For one-half to 1 gram of silicate Jannasch uses 1½ to 2 grams of borax.

Regarding the borax method, its inventor insists upon the following points as essential to success, especially when the blast can not be applied: Most thorough mixing of flux and mineral powder and a most impalpable fineness of the latter.

The borax itself is prepared by heating pure crystallized borax in a platinum dish till a small portion has melted. That remaining unfused is powdered and again heated in the dish to dull redness for fifteen minutes, with constant stirring. The powder is placed in a tube with

tightly fitting glass stopper and kept over sulphuric acid. It must not be kept long without reheating, because of being hygroscopic.

Another form of tube used by Jannasch for special purposes is shown in fig. 11. Minerals, such as topaz, which is not fully decomposed by the borax method and which contains a large amount of fluorine, are fused at *b* with about six times their weight of lead oxide. A layer of lead oxide between *c d* serves to retain any fluorine escaping from the fusion.

VI. SILICA, SEPARATION FROM ALUMINA, ETC.

ALTERNATIVE METHODS OF DECOMPOSITION.

PRELIMINARY REMARKS.

The practice of separating alumina, etc., by the usual methods, after first attacking the rock powder by hydrofluoric and sulphuric acids—silica being estimated in a separate portion—while attractive in principle, was abandoned by the writer after fair trial, owing to the disturbance sometimes occasioned by incomplete expulsion of fluorine and to a less degree by the presence of sulphates instead of chlorides. With exception of the comparatively few analyses made thus, the sodium-carbonate method has always been employed. In the case of rocks rich in fluorine strict accuracy would require the separation of silica to be made as in the Berzelian method for fluorine estimation (see footnote, p. 50), but in practice it is not often necessary to resort to this tedious procedure, since the amount of fluorine is usually small and it can by no possibility cause a loss of much more than three-fourths its own weight of silica by volatilization as silicon fluoride when the sodium-carbonate fusion is evaporated directly with hydrochloric acid. Probably the loss is less, since some fluorine perhaps escapes as hydrofluoric acid. However this may be, the error is of comparatively slight importance, since it attaches to the constituent always present in greatest amount.

Various fluxes other than alkali carbonates have been recommended for breaking up silicates insoluble in ordinary acids, such as lead and bismuth oxides, lead carbonate, borax, and boric oxide. Professor Jannasch and his pupils have been especially active of recent years in this line of work, as evidenced by their numerous published papers. One of the advantages these fluxes possess over the alkali carbonates is their removability after serving their purpose, thus allowing the various separations to be made more perfectly and without the annoying interference of several grams of foreign fixed salts, which are most troublesome in that part of the analysis devoted to the separation of silica, *alumina*, *iron*, lime, and magnesia.

Another of their advantages is that with some of them it is possible to estimate in one portion the alkalies, in addition to those constituents usually determined in the silica portion. Where the material is limited, as it so often is in mineral analysis, this is a most important advantage, sufficient to outweigh all possible objections; but in rock analysis, where the supply of material is usually ample, it is rarely worth considering. A still further point in their favor is that it is probably more easy to obtain them entirely free from fixed impurities than an alkali carbonate.

There are, however, objections to their use. With some of them an extraordinary amount of time must be devoted to grinding the mineral to an impalpable powder, and the flux itself may need considerable hand pulverization. Once introduced, they must be removed before the analysis can be proceeded with, and this removal takes much time and is always a possible source of error.

In mineral analysis these objections are entitled to far less weight than in rock analysis, since the object sought—usually the deduction of a formula—warrants the expenditure of much time and painstaking care. Finally, it has been found that one or more of these fluxes are not available for altogether general use, since certain minerals do not fully succumb to their attack under simple conditions, as andalusite with boric oxide and others with lead oxide (Jannasch). Therefore, however well adapted one or the other of these methods may be for the analysis of homogeneous minerals, it is very improbable that the vivid anticipations of Professor Jannasch, to the effect that the boric-oxide method will soon supersede the alkali-carbonate-fusion method in rock as well as in mineral analysis, will be speedily realized. Nevertheless, the boric-oxide-fusion method, owing to its evident merit, will be described in detail after brief reference to a means of bringing refractory silicates into solution without employing any solid reagent.

DECOMPOSITION OF REFRACTORY SILICATES BY HYDROCHLORIC ACID UNDER PRESSURE.

Jannasch[1] pours upon the finely ground rock powder contained in a platinum tube of about 26 cm.^{3} capacity a somewhat diluted hydrochloric acid (4 acid to 1 water), places over the open end a cap which does not hermetically close the tube, inserts the latter in a larger one of potash glass likewise partially filled with the diluted acid, seals the glass tube, and places it in turn in an inclined position in a steel Mannesmann tube containing ether or benzine to equalize the pressure, and heats to any desired temperature up to 400° C.

The chief drawback seems to be a somewhat incomplete decomposition, doubtless due to the necessarily inclined position of the tube, which causes the powder to collect at the lower end, and thus renders

[1] Ber. deutsch. chem. Gesell., Vol. XXIV, p. 273, 1891, and Zeitschr. für anorg. Chem., Vol. VI, p. 72, 1894.

decomposition less complete than if the material were spread evenly throughout the length of the tube. Further, the acid strongly attacks the platinum unless the air in both the platinum and the glass tubes is replaced by carbon dioxide. Even when this is done, several milligrams of platinum are found in the silicate solution.

Nevertheless, to those possessing the necessary platinum and steel tubes the method can render efficient service in special cases when economy of material is imperative.

THE BORIC OXIDE METHOD OF JANNASCH AND HEIDENREICH.[1]

Preparation of the boric oxide.—This demands, if the alkalies are to be estimated in the same portion as silica, etc., an absolutely alkali-free boric acid, which can be prepared by two or three recrystallizations of a good commercial article. The purified crystals are dehydrated and fused in a large platinum crucible. This is then suddenly cooled to cause the anhydride to crack into pieces of a size convenient for powdering, which are to be kept in a tight glass and powdered as needed, since the anhydrous oxide is hygroscopic.

Treatment of easily decomposable silicates.—To this flux Jannasch and Heidenreich find that nearly all silicates readily succumb over the ordinary blast lamp. The fusion is made in a large crucible holding 40–65 cm.^{3}, and the proportion of flux to be used is gauged according to the nature of the silicate, ranging from 3 to 8 and more parts to 1 of mineral. This last must be finely powdered, especially the most resistant, the authors recommending the expenditure of one-half to one hour's time for the grinding of one-half to 1 gram of powder. A low burner heat is applied for five to ten minutes till water is expelled, which is then gradually increased till the gas is fully turned on. Bubbling and rising in the crucible is prevented as far as possible by using a short platinum rod which does not reach above the edge of the crucible. When the mass has been in quiet fusion for a time in the covered crucible the blast flame is applied. The average duration of the entire operation is twenty to thirty minutes, but depends much on the character of the mineral.

Treatment of refractory silicates.—For those minerals which, like andalusite, cyanite, and topaz, are not fully decomposable by the heat of the ordinary blast flame, Jannasch and Weber[2] use a flame fed by oxygen instead of air. The blast lamp, of 2½ mm. opening, is supplied with gas from at least five or six ordinary gas cocks, and the flame is made broad and free from luminosity. The mineral having been first heated as above described, but with a much larger proportion of flux—as high as 30 to 1—a few grams additional of boric oxide

[1] Zeitschr. für anorg. Chem., Vol. XII, p. 208, 1896.
[2] Ber. deutsch. chem. Gesell., XXXII, p. 1670, 1899.

are added and the oxygen blast is applied till, in ten or fifteen minutes, the fusion is as transparant as glass.[1]

Further treatment after fusion.—From this point the further treatment is the same in both cases, and as modified by Jannasch and Weber (loc. cit.) is as follows:

The hot crucible is cooled in cold water and the contents are turned into a very large porcelain or platinum dish, to which, after covering with a glass, a saturated solution of hydrochloric acid gas in methyl alcohol is added.[2] The cover being then removed, the liquid is heated to boiling over asbestos board by an inch-high flame, stirring constantly, or it is left without attention over a lower flame or on a water bath heated short of boiling. The crucible is cleansed in a similar manner, and its contents are added to the dish. In ten to fifteen minutes, with occasional addition of the methyl chloride, solution is complete and the liquid is then boiled down to a small volume and evaporated to dryness on the bath. The residue is then digested on a bath at 80° to 85° C. three or four times in succession, with the ether solution, in order to remove the last traces of boron as boric ether. Care should be taken to wash down from the sides of the dish, with methyl-chloride solution, the boric acid formed and deposited thereon during the evaporation.

Possible objections to the boric-oxide method.—Very much is claimed by Jannasch for this method, but with all its undoubted merit there are two points which may militate against it in time. The boric ether, driven off in such enormous quantities, at once decomposes in contact with moisture, and boric acid settles over all objects with which it comes in contact. The hood must become thickly coated. Hence a special hood for these evaporations alone seems to be called for, otherwise boric acid may at any time fall into other dishes and cause untold trouble. The second objection attaches to the use of the oxygen flame when alkalies are to be estimated in the fusion, and the ability to so determine them is one of Jannasch's chief claims in favor of the method, for it can not be doubted that at the high temperature of this flame alkalies are volatilized in part. Borax can be slowly but wholly volatilized over the ordinary blast, hence there is great reason to fear sufficient loss at this much higher temperature to give rise to serious error at times.

THE SODIUM-CARBONATE METHOD.

Purity of the sodium carbonate used as a flux.—Notwithstanding the most earnest efforts for years, it has been impossible to procure, either

[1] An interesting and important observation reported by Jannasch and Weber is that when the oxygen blast has been used for silicates carrying fluorine or mixed with fluorides, the fluorine seems to be wholly expelled as boric fluoride, without loss of silica. If this should prove to be generally true, an easy way is at last afforded for estimating silica in such cases, where even its detection, when present in small amount, has heretofore been difficult.

[2] Made by passing dry HCl into cooled CH_4O for from one to two hours.

in the open market or by special arrangement *with manufacturers, an* article of sodium carbonate which can be called chemically pure. With special precautions small lots can be prepared in the laboratory that will contain less than 1 milligram total impurity in 10 grams; but such an article can not be purchased in the market, and rarely will the so-called chemically pure dry sodium carbonate contain as little as 1 milligram in 10 grams. The invariable contaminating substances, aside from sand and straw, which have sometimes been found in large amount, are silica, alumina, iron, lime, and magnesia, all of these going into aqueous solution with the carbonate. The chief of these impurities are usually silica, alumina, and lime. An article of the above degree of purity is satisfactory in almost all imaginable cases, since the use of the usually extravagant amount of 10 grams for a fusion would introduce an error of but 0.1 per cent in the analysis, supposing 1 gram of mineral to be operated on, and it would, moreover, be distributed over several constituents. This error is undoubtedly fully equaled by the introduction of dust from the air in the various long evaporations.

Precautions in fusing.—Special directions with regard to the fusion and its first treatment are unnecessary, except to say that ordinarily from 4 to 6 parts of flux should be used to 1 of rock and that the flame should not be directed vertically against the bottom of the crucible, but at an angle against the side and bottom, nor should the flame be allowed to envelop the whole crucible. These precautions apply in all ignitions of reducible substances, and yet they are rarely observed. In neither case, if neglected, will there be the necessary oxidizing atmosphere within the crucible; on the contrary, reduction may occur fraught with serious consequences. This is especially true if the rock contains more than traces of pyrite or other sulphide, when, after cleansing and igniting the crucible, there may appear on its interior a darkening due to oxidation of reduced iron which had alloyed with the platinum. This may in exceptional cases amount to several milligrams in weight, and can be removed only by repeated ignitions, followed each time by scouring or treatment with hydrochloric acid or acid potassium sulphate. In order to avoid the use of niter in case of pyritiferous rocks, it is well to first roast the weighed powder in the crucible in which the fusion is to be made.

Treatment after fusion.—When fusion is complete, the crucible is seized with the tongs (fig. 1, p. 23) and the contents are caused to solidify in a thin sheet over the sides and bottom by imparting an appropriate rotating motion with the arm during the cooling process. This is far preferable to allowing the melt to form a thick cake at the bottom, since much less time is required for disintegration, and separation from the crucible is usually much easier.

It sometimes happens that the cooled flux, and even its solution,

will indicate absence of manganese when it is really present in quantity to give normally a strong coloration. Two fusions made side by side or successively, under apparently similar conditions, may in one case show little or no manganese, in the other considerable. This observation has been frequently made, and therefore the absence of a bluish-green color in the fusion is not to be taken as proof of the absence of manganese. This difference of behavior I can ascribe to no other cause than that of a reducing atmosphere in one of the crucibles and an oxidizing one in the other, even though the conditions were apparently alike.

The contents of the crucible are placed in a rather tall covered beaker with some water, and hydrochloric acid of 1.1 specific gravity is added in excess. The depth of the pink color usually produced on addition of the acid allows of judging approximately as to the amount of manganese present. The beaker is placed on the water bath, and when disintegration is complete, having been assisted by gentle pressure with a blunt glass rod, the contents are transferred to a large platinum dish and evaporated on the bath.

SUBSEQUENT TREATMENT.

From this point the treatment will ordinarily be the same whether the boric-oxide or the sodium-carbonate method of decomposition has been employed.

Drying and testing of silica.—As to the best way of rendering silica insoluble by evaporation, the writer's predilection is for a double evaporation instead of a single one on the water bath. By fusing with sodium carbonate in the forenoon, the silica is ready for the first filtration in the afternoon. It is quite unnecessary to carry the evaporation beyond approximate dryness. The filtrate is again evaporated, always in platinum, and is ready for final filtration the following morning, when approximately 1 per cent of silica is recovered and added to the main portion. The writer's experience is that a better separation of silica is effected hereby, and in no more time than by a single long evaporation. That which is subsequently recovered from the precipitate of alumina, etc. (p. 56), rarely exceeds a half or, at the most, 1 milligram.

Drying in an air bath at 110° C. or higher, or on a hot plate or sand bath, or over a free flame, in order to render silica insoluble, offers no advantage unless much magnesium is present, and then the most favorable temperature, according to Gilbert,[1] is 120° C. The presence of much calcium chloride seems to facilitate dehydration of the silica, while magnesium chloride above 120° C., on the other hand, by decomposing, forms a silicate which dissolves in hydrochloric acid and

[1] *Technology Quarterly*, Vol. III, p. 61, 1890. Abstract in Fresenius's Zeitschr. für anal. Chemie, Vol. XXIX, p. 688, 1890.

increases the amount of silica carried into the filtrate. It does not appear from Gilbert's paper that the blast-furnace slags, on which he experimented, contained titanium, phosphorus, or iron in appreciable amounts. Basic magnesian rocks usually do, and in such cases it is probable that the employment of a drying temperature of 120° would materially add to the large impurity always to be expected with the silica. In other cases he confirms the earlier belief that drying temperatures higher than that of the water bath increase the amount of insoluble impurity, chiefly alumina, in the silica, and that this amount can not be reduced by long digestion with hydrochloric acid. Further, he confirms Lindo's statement that evaporation with sulphuric acid till the appearance of white fumes gives a higher result in silica than with hydrochloric acid. But for general rock analysis the use of sulphuric acid at this stage must be rejected utterly.

Blasting for twenty to thirty minutes[1] is necessary to expel all moisture from the silica, and it is then not hygroscopic. Its weight should always be corrected for impurities, which are never absent, by evaporating with hydrofluoric and sulphuric acids and again blasting. If toward the end of evaporation with these acids, when the hydrofluoric acid has been driven off and the sulphates begin to appear in solid form, the residue has a peculiar milky or enamel-like appearance, it may be taken as evidence of much phosphorus and titanium. This appearance is possibly due to zirconium with the phosphorus and titanium,[2] and is so unusual and striking that it is worth while calling attention to it. With basic rocks very rich in titanium and phosphorus the residue may amount to 2 or even 3 per cent of the rock.

The subsequent precipitate of alumina, etc., is usually ignited in the crucible containing the residue from the silica.

It might be supposed that this residue would contain most of the barium of those rocks carrying that element, together with sulphur or sulphates, but the reverse is true as a rule. Only when there is a considerable excess of SO_3 over the BaO will much of the latter be found there, and in the vast majority of cases there is none at all. Should some be present, its removal and estimation at this stage is not necessary, as it can be more conveniently recovered later, together with the silica accompanying the alumina, etc., precipitate (p. 56).

The separation of silica in rocks containing fluorine has been touched upon in commenting on the boric-oxide and sodium-carbonate methods of fusion,[3] and will be considered further under the head of Fluorine (p. 103).

[1] It must be borne well in mind that some platinum crucibles lose weight steadily and very appreciably on long blasting, not only when new but even after long use. When a crucible suffers from this defect the rate of loss should be ascertained from time to time and allowance made accordingly, or else the weight of the crucible should be taken after and not before ignition of the precipitate. (See on this subject Hall, Jour. Am. Chem. Soc., Vol. XXII, p. 494, 1900.)

[2] See first *footnote, p. 57.*

[3] *See p. 47 and footnote, p 50.*

Platinum in filtrates.—The filtrates from the silica always contain notable amounts of platinum. This arises in very small degree from the crucible fusion, in a larger one indirectly from the action of hydrochloric acid on manganate, vanadate, and sometimes chromate of sodium, and, if much iron is present, in no small degree from the reduction of ferric chloride to ferrous by the platinum of the dish. This last reaction is little known, apparently, but is mentioned in Gmelin-Kraut,[1] and can be readily demonstrated by evaporation of ferric chloride in platinum.

The removal of this platinum before precipitating alumina and iron is not necessary (but see second footnote, p. 57), and to do so involves the reoxidation of all iron and subsequent boiling to remove or destroy the excess of oxidizing agent, together with the expenditure of much valuable time. The iron is already oxidized by the fusion, and needs no further help in that direction. Nevertheless, if time is not a prime object, its removal by hydrogen sulphide is to be recommended. In the following descriptions, however, it is assumed that the platinum has not been gotten rid of at this stage.

VII. METALS PRECIPITABLE BY HYDROGEN SULPHIDE.

The presence in appreciable amounts of metals precipitable by hydrogen sulphide, except perhaps copper, is of such infrequent occurrence in most rocks that discussion is unnecessary in their connection. In case it is necessary to precipitate them at this stage, however, it is always well to bear in mind that a little titanium may be thrown down along with them. Separations of the silica should be made in porcelain, to eliminate platinum, or, better still, the quantitative estimation of these metals should be made in a separate portion of the rock broken up by the action of hydrofluoric and sulphuric acids.

VIII. ALUMINUM. TOTAL IRON.

INDIRECT METHOD FOR ALUMINUM.

The common practice in this laboratory is to find alumina by difference after deducting from the precipitate produced by ammonia or sodium acetate the sum of all other oxides this precipitate may contain. Of these, only ferric oxide, titanic oxide, and the trace of silica are determined in this portion (see also second footnote, p. 57), those of phosphorus, vanadium, chromium, and zirconium being looked for in other portions of the rock powder. This throws upon the alumina all errors involved in their separate determinations; but these may balance, and

[1] Anorg. Chem., Vol. III, p. 359. Sixth revised edition.

in any case the probable error can hardly be as high as that involved in the direct weighing of the alumina itself, considering the difficulty of effecting a satisfactory separation of it from all the other admixtures, an operation which would, moreover, immoderately extend the time required for each analysis.

PRECIPITATION OF ALUMINUM, IRON, ETC.

Precipitation by ammonia.—Two precipitations by ammonia at boiling heat are usually quite sufficient to separate iron, aluminum, phosphorus, vanadium, chromium, titanium, and zirconium, if all these are present, from nickel, manganese, the alkaline-earth metals, and magnesium, provided ammoniacal salts are present in sufficient quantity. This last point is of special importance as regards magnesium, and failure to observe it is doubtless the reason why many old analyses, and sometimes modern ones, show utterly improbable percentages of alumina, especially as chemists were formerly often satisfied with a single precipitation. The necessary ammonium chloride is better obtained by the use of purified ammonia water and hydrochloric acid than by the addition of the solid salt, which is seldom pure.

Precipitation by the basic acetate method.—But it will occasionally happen that the separation from even very small amounts of manganese is altogether incomplete, and the uncertainty of insuring this separation has led the writer of late to employ the basic acetate method for the first precipitation in all cases where manganese is present—and the exceptions are few—even though the precipitation of alumina is sometimes less complete than by ammonia, and in spite of other admitted defects, as, for instance, a tendency of the precipitate to run through the filter on washing.[1] Not more than 2, or at most 3, grams of sodium acetate need be used. After slight washing and sucking dry at the pump, the precipitate is redissolved in a large excess of hydrochloric acid and reprecipitated by ammonia in slight excess. The complete boiling off of this excess is unnecessary, as pointed out by Genth and Penfield, since it is apparently the washing with pure water and not the free ammonia which carries small amounts of alumina into the filtrate. Penfield and Harper[2] recommend washing with a dilute solution of ammonium nitrate (20 cm.^{3} nitric acid, neutralized by ammonia, to the liter), and also the solution of the first precipitate in nitric instead of hydrochloric acid, in order to shorten the washing, there being no chloride to remove.

[1] The fact must not be overlooked that certain of the rare earths may pass completely into the filtrate if the basic acetate method is followed. If then, later, on rendering the combined filtrates ammoniacal, an unexpectedly large precipitate appears, this should be carefully examined as to its nature. In an analysis of piedmontite from Maryland over 2 per cent of rare earths, including cerium and others not identified, were quantitatively separated in this way from iron, alumina, etc.

[2] Am. Jour. Sci., 3d series, Vol. XXXII, p. 112, 1886.

The filtrates are strongly concentrated separately[1] in platinum, a drop or two of ammonia being added toward the end to the second one, and filtered successively through the same small filter into a flask of 150 to 200 cm.^{3} capacity, the ammoniacal filtrate serving as wash water for the first dish and containing enough ammoniacal salt to prevent precipitation of magnesium in the first filtrate when mixed with it. If manganese has been deposited upon the surface of the dish it is removed by hydrochloric and a drop or two of sulphurous acids, which mixture is then passed hot through the filter. A reprecipitation by ammonia is then made, and the precipitate collected again on the filter and added to the main one, the filtrate passing into the flask containing the previous one. If much manganese is present, of course a second precipitation by ammonia of the small precipitate may be required. In these cases there is no difficulty in getting all the manganese into the filtrate.

IGNITION OF THE PRECIPITATE.

The combined precipitates of alumina, etc., are ignited moist, in the paper, unless considerable iron is present, when the main one is dried, removed as far as possible from the paper, and the latter ignited separately to prevent partial reduction of a portion of the iron, which can not then be wholly reoxidized by heating or by treatment with nitric acid (see p. 38).

Alumina in the quantities ordinarily found can not be fully dehydrated by the full heat of the Bunsen burner. It must be blasted for five or ten minutes. If iron is present in large amount this last operation must be conducted so as to insure free access of air to the crucible (p. 51).

RECOVERY OF SILICA AND POSSIBLE BARIUM IN THE ALUMINA PRECIPITATE.

The precipitate is dissolved by fusion with acid potassium sulphate, an operation which is accomplished without trouble in from two to four hours if the temperature is kept low and the acid salt has been properly made free from water and excess of acid. The melt is taken up with hot water and considerable dilute sulphuric acid, the residue collected, weighed, and corrected by hydrofluoric and sulphuric acids for silica, which, as said before, rarely amounts to 1 milligram in weight, and further examined for barium (see p. 53) by dissolving any

[1] If, instead of sodium acetate, ammonia alone has been used to precipitate alumina, etc., it has sometimes happened in the experience of others than the writer that on concentration of the first filtrate a pale straw-colored precipitate appeared, which remained on the filter with the traces of alumina that may also separate, although it is slowly soluble in hot water. This is said to be some compound of platinum, and attention is called to it here for the guidance of others who may notice it and be unaware of its character.

remaining residue in hot, strong sulphuric acid and diluting with cold water.[1]

ESTIMATION OF IRON IN THE PRECIPITATE OF ALUMINA, ETC.

Without regard to the presence of vanadium.—The filtrate obtained in the preceding paragraph is reduced, hot, by hydrogen sulphide, boiled to collect sulphur and the platinum sulphide[2] resulting from the bisulphate fusion, the hydrogen sulphide being allowed to pass for a short time after boiling. It is then filtered[3] hot into a flask attached to a carbonic-acid apparatus and brought to boiling to expel hydrogen sulphide. When this is fully effected the flask is cooled in water while the carbon dioxide still passes, and the solution is then titrated by potassium permanganate. The results are strictly accurate, with the limitations set forth in the paragraph below, when care is taken with the reduction by hydrogen sulphide. The method is altogether superior to that involving the use of zinc, since no foreign impurity affecting the result is introduced and the ever-present titanium is not affected, nor is vanadium reduced below the condition of V_2O_4, whereas nascent hydrogen converts it, in part at least, to V_2O_3. Titanium can be conveniently estimated by adding hydrogen peroxide to the titrated iron solution (see p. 68).

[1] Some years ago, in a series of analyses of rocks from the Leucite Hills, in Wyoming, there was obtained at this stage, when it was customary to dissolve the melt in cold water preliminary to precipitation of titanium by boiling the neutralized sulphuric solution in presence of sulphur dioxide, a white, more or less flocculent residue amounting to 1 to 3 per cent of the rock, which was at first taken to be a mixture of tantalic and columbic acids. Eventually it was found to consist apparently of nothing but TiO_2 and P_2O_5, with perhaps a little ZrO_2. By repeated fusion with acid potassium sulphate and leaching with cold water it could be gradually brought into solution. It was these rocks which furnished the most striking instance of the peculiar, milky, sulphate residues mentioned on p. 53, as derived from the ignited silica.

Knop (Zeitschr. für Kryst., Vol. X, p. 73, 1885) seems to have obtained a similar mixture in analyzing minerals from the Kaiserstuhl in Baden, but its nature was not ascertained, though suspected to be, if not silica, columbiferous titanic acid.

[2] It may be mentioned that the precipitation of platinum from a hot sulphate solution is far quicker and cleaner than from hydrochloric acid. Further, this platinum sulphide, when ignited in the crucible in which the bisulphate fusion was made, should weigh together with the crucible itself what the latter weighed before the main silica precipitate was ignited in it; in other words, the weight of the platinum recovered by hydrogen sulphide should equal the loss in weight of the crucible due to attack by the bisulphate. In somewhat rare instances this will not be so, but the weight will be greater, showing a gain in platinum which may amount to a milligram. Tests have shown that this is not due to retention of platinum by the main Al_2O_3, etc., precipitate; hence, it must come from platinum mechanically loosened from the dish during the drying and powdering of the silica preparatory to its collection on the filter, or to some insoluble compound of platinum formed during evaporation and drying of the silica. It may also be in part or wholly due to contamination from reduction of platinum during evaporation of the filtrate from the basic acetate separation. It will be remembered that from this filtrate a small amount of iron and alumina is recovered and added to the main precipitate. Hence it is always well in fine work to collect the sulphide and weigh the platinum in the original crucible, deducting any excess from the alumina, or else to get rid of the platinum by hydrogen sulphide before proceeding to the precipitation of alumina, etc. (see p. 54).

[3] Filtration is not necessary if only precipitated sulphur and no sulphides are in suspension, since this is without reducing action on cold permanganate solution, as Wells and Mitchell, and others before them, have pointed out. The above authors used this method of reducing ferric iron in titanic iron ores. (Jour. Am. Chem. Soc., Vol. XVII, p. 78, 1895; also Chemical News, Vol. LXXIII, p. 123, 1896.)

Having regard to the presence of vanadium.—If vanadium is present the value found for iron will be in error by the amount of permanganate required to oxidize V_2O_4 to V_2O_5. The amount of the correction will differ according as titration of the iron is made after reduction by hydrogen sulphide or by nascent hydrogen. If the former is used, as should always be the case, because of the ever present titanium, the vanadium is reduced by it to V_2O_4, which in its action on permanganate is equivalent to two molecules of FeO, while the reduction goes further with hydrogen. After the first transitory pink blush throughout the liquid, the slower-acting vanadium may require the addition of a drop or two more of permanganate before a comparatively permanent coloration appears.

When the amount of vanadium in the rock is known a correction can be applied on the assumption that practically all the vanadium is here collected, a point that needs further investigation. Various authors assert its precipitability with alumina and iron by ammonia and ammonium-acetate, though Carnot[1] states that repeated precipitation by ammonia, ammonium carbonate, or ammonium sulphydrate, separates it from iron. The writer's experience with ores very rich in vanadium shows that precipitation along with iron and aluminum is only partial. Ridsdale[2] has determined its precipitability with various metals and gives numerous figures which show an approximation to 90 per cent thus thrown down under the conditions prevailing in analysis of iron slags, the remainder passing into the filtrates and appearing in small part with the lime and to a greater extent with the magnesium phosphate. For all practical purposes it is probably safe to assume that the small amounts of vanadium met with in rocks are wholly in the alumina precipitate.

If the amount of vanadium in the rock is not known and great accuracy is necessary, caution requires the determination of the total iron to be made either in a separate portion or after reprecipitation from the above solution, as follows: Fuse with sodium carbonate, extract with water, bring the insoluble residue into sulphuric solution, reduce and titrate as above directed. But unless a certain precaution is here observed an error greater than that which it is designed to avoid will be committed. Contrary to general belief the aqueous extract from the sodium-carbonate fusion carries a small but appreciable fraction of a per cent of iron, as the writer has repeatedly found by actual test. This iron is thrown out with the alumina (and silica, if present) by the usual methods of neutralizing the alkaline solution, and can be brought to light when the precipitate thus formed is treated with a fixed caustic alkali, or again fused with sodium carbonate and leached with water,

[1] Comptes Rendus, Vol. CIV, p. 1803, 1887; Zeitschr. für. anal. Chem., Vol. XXXII, p. 223, 1893.
[2] Jour. Soc. Chem. Industry, Vol. VII, p. 73, 1888.

when it remains wholly or in part undissolved. *Hence it is necessary* to collect this iron and add it to the main portion before titration.

DETERMINATION OF THE TRUE VALUE FOR FERRIC IRON.

Having in one way or another found the total iron in the rock, it remains to deduct an amount equivalent to the ferrous oxide the rock contains, and a further amount corresponding to the sulphides often present, in order to get what may pass for the true value for ferric iron. That this is often only an approximation appears from the difficulties due to the presence of vanadium and the generally indeterminable effect of sulphides on the ferrous oxide determination. (See pp. 94–96.)

METHODS AIMING AT THE MORE OR LESS DIRECT ESTIMATION OF ALUMINUM.

AFTER FIRST REMOVING IRON AS SULPHIDE.

Should it be desirable for any reason to effect an actual separation of aluminum, this may best be done, up to a certain point, after the bisulphate fusion (p. 56), by removal of the iron[1] by ammonium sulphide in ammonium tartrate solution, evaporation of the filtrate, ignition of the residue with sodium carbonate and nitrate, and extraction with water, whereby titanium and zirconium are left on the filter as sodium salts while chromium and vanadium are carried into the filtrate as chromate and vanadate along with aluminum and phosphorus. The further separation of the two last from the chromium and vanadium is outlined under Phosphorus, p. 79. This is as far as the separation can well be carried, and the Al_2O_3 must still be found by subtracting the P_2O_5 from the combined weights of the Al_2O_3 and P_2O_5. The possibility of loss of some P_2O_5 by volatilization[2] during the bisulphate fusion must be borne in mind here, for if it takes place the final weight of $Al_2O_3 + P_2O_5$ will not contain all the P_2O_5.

Some writers recommend dissolving the ignited alumina, iron oxide, etc., in hydrochloric acid, but when the precipitate has been heated over the blast, as it should be, this is very ineffective.

BY EXTRACTION WITH A FIXED CAUSTIC ALKALI.

A favorite practice in some countries of Europe is to fuse the ignited precipitate containing Al_2O_3, Fe_2O_3, TiO_2, P_2O_5, etc.—or that of the Al_2O_3, TiO_2, P_2O_5, etc., after separation of iron by ammonium sulphide in tartrate solution—with sodium hydroxide in a silver crucible, or to

[1] This being first reduced to the ferrous condition by hydrogen sulphide in acid solution in order to obviate the possibility of precipitating some titanium, which otherwise is likely to happen. (Cáthrein, Zeitschr. für Kryst., Vol. VI, p. 246, 1882, and Vol. VII, p. 250, 1883.)

[2] H. Rose speaks of such loss when volatilizing sulphuric acid in presence of phosphoric acid. (Handb. f. quant. Anal., Finkener edition, Vol. II, p. 575, and elsewhere.)

boil the freshly precipitated mixture with a solution of the alkali, on the assumption that the titanium oxide is hereby rendered wholly insoluble and thus separated from the alumina. This, however, is in part an error long since pointed out by Gooch,[1] who showed that pure titanic oxide is markedly soluble under both conditions of treatment. Experiments very recently made by the writer to test the extent of this error brought out the following interesting results.

When 0.045 gram of titanic oxide was fused by itself with sodium hydroxide, the clear aqueous extract of the fusion held 0.0031 TiO_2, or about 7 per cent, determined colorimetrically. When freshly precipitated and boiled with the alkali the solubility was less. When fused with sodium carbonate but an infinitesimal trace was dissolved, which required strong concentration for its detection. When mixed with a large excess of alumina and fused with the caustic alkali, the solubility was still very marked, though less than when alumina was absent. With a large excess of ferric oxide, with or without alumina, no titanium could be detected in the unconcentrated filtrate.

It thus appears that fusion with caustic alkali after first removing iron involves an error in the gravimetric determination of both aluminum and titanium which does not appear if the iron has not been removed.

DIRECT PRECIPITATION OF ALUMINA.

A recent and promising method for the "direct determination of alumina in presence of iron, manganese, calcium, and magnesium" is that of Hess and Campbell,[2] but, as with the methods just considered, it involves finally weighing aluminum and phosphorus together, and the behavior of titanium has not been investigated. For this latter reason the details of the method will not be given. Suffice it to say that precipitation of the aluminum and phosphorus is made by phenylhydrazine, after first neutralizing the (preferably chloride) solution by ammonia and reducing iron by a saturated solution of ammonium bisulphite. Phenylhydrazine "precipitates aluminum from its solutions quantitatively as the hydroxide without a trace of the precipitate being redissolved in excess of the precipitant."

IX. MANGANESE, NICKEL, COBALT, COPPER, ZINC.

Ammonia is added to the flask containing manganese, the earths, etc. (p. 56), and hydrogen sulphide gas is introduced, whereby manganese, nickel, cobalt, copper, zinc, and a small part of the platinum from the dish are precipitated. The flask is set aside, corked, for at least twelve hours, and preferably twenty-four, or even longer; the pre-

[1] *Proc. Am. Acad. Arts* and Sci., Vol. XII, p. 436, 1885; Bull. U. S. Geol. Survey No. 27, pp. 16 and 17.
[2] *Jour. Am. Chem. Soc.*, Vol. XXI, p. 776, 1899; Chemical News, Vol. LXXXI, p. 158, 1900.

cipitate, collected and washed on a small filter with water containing ammonium chloride and sulphide, is extracted by hydrogen-sulphide water acidified with one-fifth its volume of hydrochloric acid (sp. gr. 1.11), manganese and zinc, if present, going into solution.

MANGANESE AND ZINC.

The filtrate is evaporated to dryness, ammonium salts are destroyed by evaporation with a few drops of sodium-carbonate solution, hydrochloric and a drop of sulphurous acids are added to decompose excess of carbonate and to dissolve precipitated manganese, and the latter is reprecipitated at boiling heat by sodium carbonate after evaporation of the hydrochloric acid. If zinc is present, it can be separated from the manganese after weighing. For the small quantities of manganese usually found the sodium-carbonate method of precipitation is to be preferred to that by bromine or sodium phosphate, as equally accurate and a great time saver.

The precipitation of manganese in alkaline solution by hydrogen peroxide, as proposed by Jannasch and Cloedt,[1] a method which appeared to be simple and accurate, besides affording a separation from zinc, has been shown by Friedheim and Brühl[2] to be valueless, as also other separation methods of Jannasch based on the use of hydrogen peroxide.

The employment of ammonium sulphide instead of bromine for the separation of manganese from the alkaline earths and magnesia has the advantage that, by a single operation, nickel, copper, and zinc are likewise removed if present. There need be no fear of overlooking nickel or copper, for under the conditions of the precipitation they are not held in solution. Now and then a trace of alumina may be found in the precipitate, and magnesia, too, would contaminate it if ammonium salts were not present in sufficient quantity. Regard must therefore be had to these possibilities, and also to the rather remote possibility of the presence of rare earths which were not thrown out by the basic acetate precipitation (see footnote, p. 55).

NICKEL, COBALT, COPPER.

The paper containing these is incinerated in porcelain, dissolved in a few drops of aqua regia, evaporated with hydrochloric acid, the copper and platinum thrown out warm by hydrogen sulphide, and nickel and cobalt thrown down from the ammoniacal filtrate by hydrogen sulphide. This is then rendered faintly acid by acetic acid and allowed to stand. The sulphide of nickel is simply burned and weighed as

[1] Zeitschr. für anorg. Chemie, Vol. X, p. 405, 1895.
[2] *Zeitschr.* für anal. Chemie, Vol. XXXVIII, p. 681, 1899.

oxide, its weight being always very small, and is then tested for cobalt in the borax bead.

It is somewhat unsafe to consider traces of copper found at this stage to belong to the rock if the evaporations have been conducted, as is usually the case, on a copper water bath, or if water has been used which has been boiled in a copper kettle, even if tinned inside. Therefore, and because of its contamination by a little platinum, it is better to determine copper in a separate portion if its presence is indicated with certainty. (See p. 54.)

X. CALCIUM AND STRONTIUM (BARIUM).

SEPARATION FROM MAGNESIUM.

Precipitation and ignition of the oxalates together.—The platinum derived from the dish in the silica evaporation, except for the small portion precipitated with the manganese sulphide, is now wholly in the filtrate from the latter. Its separation at this or any other stage is quite unnecessary; nor is the removal of ammonium chloride usually demanded, since there is no undue amount present in most cases, the first precipitation of alumina, etc., having been by sodium acetate.[1] Therefore, without destroying ammonium sulphide the calcium and strontium are thrown out by ammonium oxalate at boiling heat, the precipitate, often darkened by deposited platinum sulphide, is ignited and redissolved in hydrochloric acid, boiled with ammonia to throw out traces of alumina sometimes present and reprecipitated as before, but in a small bulk of solution. It is weighed as oxide, transferred to a small flask of 20 cm.^{3} capacity, dissolved in nitric acid, evaporated to dryness at 150 to 160° C., and the separation of strontium from calcium effected by ether-alcohol[2] as described below.

The weight of strontia found deducted from that of the two oxides gives that of the lime.

Necessity for two precipitations by ammonium oxalate.—It may be said with regard to the separation of calcium from magnesium that two precipitations by ammonium oxalate are essential to the attainment of correct results, not only for the complete removal of magnesium but of sodium as well, the retention of compounds of the latter element by calcium oxalate being now generally known. For the treatment of the filtrates, see Magnesium, p. 64.

[1] If two or three precipitations by ammonia alone are depended on, the second and third filtrates are evaporated rapidly to dryness and the ammonium salts removed by ignition.

[2] See Fresenius: Zeitschr. für anal. Chemie, Vol. XXXII, pp. 189, 312, 1893, for the latest improvements in this method.

SEPARATION OF STRONTIUM (BARIUM) FROM CALCIUM BY ETHER-ALCOHOL.

The thoroughly dried nitrates are treated with as little (rarely over 2 cm.^{3}) of a mixture in equal parts of absolute alcohol and ether as may be needed to dissolve the calcium salt, solution being hastened by occasional gentle agitation. After standing over night in a corked flask the insoluble matter is collected on the smallest possible filter and washed with more of the above mixture of alcohol and ether. After drying, a few cubic centimeters of hot water are passed through the filter, on which may remain a few tenths of a milligram of residue which does not usually contain any lime or other alkaline earth and whose weight is therefore to be deducted from that of the lime, unless it can be shown that it is derived from the glass of the little flask in which the nitrates of calcium and strontium were evaporated. To the solution of strontium nitrate in a small beaker sulphuric acid and then alcohol is added, whereby the strontium is precipitated as sulphate, in which form it is weighed and then tested spectroscopically as to freedom from calcium and barium.

Because of the slight solubility of strontium nitrate in amyl alcohol the method of Browning[1] does not appear to be adapted to the separation from calcium of the small amounts of strontium met with in rocks, though with barium the case is different, since its nitrate according to Browning is insoluble in absolute amyl alcohol.

BEHAVIOR OF BARIUM.

Barium will, after two ammonium oxalate precipitations, never be found with the ignited calcium and strontium in more than spectroscopic traces, unless originally present in excess of 3 or 4 milligrams, and very often only when in considerable excess.[2] If present with them, however, it will be separated with the strontium by ether-alcohol or amyl alcohol, and these two must then be treated by the ammonium-chromate method, given below, in order to arrive at the strontium. The barium is best estimated in a separate portion. (See Barium, p. 73.)

SEPARATION OF BARIUM FROM STRONTIUM.

Fresenius has shown[3] in what manner only a correct separation of barium and strontium can be made by the ammonium-chromate method, involving double precipitation when the amounts are at all large. This procedure is here given for the amounts used by him, but a single precipitation will suffice for the small amounts met with in rock analysis.

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[1] Am. Jour. Sci., 3d series, Vol. XLIII, pp. 50, 314, 1892.

[2] W. F. Hillebrand: Jour. Am. Chem. Soc., Vol. XVI, p. 83, 1894; Chemical News, Vol. LXIX, p. 147, 1894.

[3] Zeitschr. *für anal. Chemie*, Vol. XXIX, p. 428, 1890.

The volumes of solutions used should be largely reduced and the operations otherwise shortened.

The chlorides corresponding to 0.2774 gram BaO and 0.4864 gram SrO were dissolved in 300 cm.^{3} of water with addition of 6 drops of acetic acid (1.065 sp. gr.). To the hot solution was added an excess (10 cm.^{3}) of ammonium chromate solution (1 cm.^{3} = 0.1 gr. neutral chromate). After settling and cooling for an hour the precipitate was washed, mainly by decantation, with water holding ammonium chromate till the filtrate gave no precipitate with ammonia and ammonium carbonate (100 cm.^{3} used). The washing was continued with warm water till silver nitrate gave but a very slight reddish coloration (110 cm.^{3}). The precipitate was then washed into the precipitating dish, the filter rinsed with warm dilute nitric acid (1.2 sp. gr.), and more nitric acid (2 cm.^{3} in all) added to the dish. The solution having been diluted to 200 cm.^{3} and heated, 5 cm.^{3} of ammonium acetate solution (1 cm.^{3} = 0.31 gr. ammonium acetate) was very gradually added, and then ammonium chromate till the odor of acetic acid had wholly disappeared (10 cm.^{3}). After one hour the supernatant liquid was passed through the filter and the precipitate digested with hot water, which was then cooled; thereupon the precipitate itself was brought on the filter and washed with cold water till silver nitrate gave a scarcely perceptible reaction. The strontium was thrown down from the filtrate by ammonia and ammonium carbonate, after concentration in presence of a little nitric acid, and weighed as carbonate; or the carbonate can be redissolved, precipitated by sulphuric acid and alcohol, and weighed as sulphate. The barium is weighed as chromate after ignition, the filter being burned separately.

XI. MAGNESIUM.

PRECIPITATION.

The first precipitation of magnesium is made without special precautions in the filtrate from the first calcium oxalate separation (p. 62) by sodium-ammonium-hydrogen phosphate (microcosmic salt)[1] in indefinite decided excess and without the great excess of ammonia usually prescribed. It is not necessary to first remove ammoniacal salts unless very little magnesium is present, and then only in order to hasten precipitation. Neubauer[2] has shown that precipitation is complete even in presence of large quantities of salts of ammonium, including the oxalate. He has, however, also shown that the composition of the precipitate is largely affected by ammonium salts, and also by the way in which the

[1] *The objection* that has been made by one writer to the use of this salt instead of disodium-hydrogen phosphate is, so far as our experience teaches, entirely groundless.

[2] *Zeitschr. für angew.* Chemie, 1896, p. 435.

precipitation is made. These points are only of importance when a single precipitation is to be made or in the final of two or more, as will be discussed later.

Platinum sulphide usually strongly contaminates the separated phosphate, but this matters not, as it remains on the filter when the phosphate is redissolved in hydrochloric acid, of which not more than the amount really needed should be used. The solution thus obtained is united with that of the residue from evaporation and ignition of the second filtrate from calcium oxalate, and is diluted if necessary. A few drops of sodium-ammonium phosphate solution are now added, and ammonia in slight excess, with constant stirring till the crystalline precipitate has well formed. The large excess of ammonia of 0.96 specific gravity (one-third the original volume) usually prescribed has been shown by Gooch and Austin[1] to be quite unnecessary, in fact, disadvantageous.

Neubauer in the above-cited paper has shown, and Gooch and Austin (loc. cit.) have confirmed his statements, that it is only by working under these conditions—absence of any large excess of precipitant, of ammoniacal salts, and of ammonia—that a precipitate of normal composition is obtainable. It usually differs from the normal in containing relatively more ammonium and less magnesium—for instance, an admixture of such a molecule as $Mg(NH_4)_4(PO_4)_2$—the result being that when ignited in the ordinary way too much magnesium is found, because of formation of some metaphosphate. To obviate this error Neubauer considers it absolutely necessary to blast the precipitate for half an hour, and then to repeat the blasting for a second half hour to see if a constant weight has been reached. The phosphate is then entirely pyrophosphate, which is quite unaffected by further blasting. The intense heat has caused a decomposition of the metaphosphate with volatilization of P_2O_5, as follows: $2\ Mg(PO_3)_2 = Mg_2P_2O_7 + P_2O_5$. Neubauer worked with the usual excess of ammonia, and it remains to be seen whether by precipitating and working according to Gooch and Austin the composition of the precipitate is always close enough to the ideal $MgNH_4PO_4$ to obviate the necessity for blasting.

From the labors of Neubauer and of Gooch and Austin it is clear that the common way of adding the phosphate precipitant to the ammoniacal solution of the magnesium salt is not calculated to produce a precipitate of normal composition. The precipitant should be added to the acid solution of the magnesium, and ammonia should then be added in slight excess.

Gooch and Austin call attention to a modification proposed some years ago by Wolcott Gibbs,[2] whereby the phosphorus and magnesium

[1] Am. Jour. Sci., 4th series, Vol. VII, p. 187, 1899; Chemical News, Vol. LXXIX, pp. 233, 244, 255, 1899; Zeitschr. für anorg. Chemie, Vol. XX, p. 121, 1899.

[2] Am. Jour. Sci., 3d series, Vol. V, p. 114, 1873.

salts are first boiled together in neutral solution for a few minutes and to the cooled solution ammonia is added. The results are said to be remarkably exact.

METHODS OF COLLECTING AND IGNITING THE PRECIPITATE.

If the blast has not to be employed, the weight of the pyrophosphate can doubtless be most accurately arrived at by collecting and igniting the precipitate in a Gooch crucible, provided the asbestos felt is well constructed and not of the serpentine variety so largely on the market.

Neubauer ignites slowly in platinum after drying, without removing from the paper, applying the blast only when the carbon has been wholly burned off.[1]

Almost as exact are the two modifications of the method in use for phosphate analyses at the agricultural experiment stations at Danzig and Lisbon, described by Schmoeger[2] and Mastbaum.[3] According to the former the precipitate after drying is detached from the paper and placed in a platinum crucible, followed by the folded filter. To the covered crucible the full flame of a burner is applied, and after a short time the burning off of the carbon is accomplished with the crucible open. A short blasting follows. In a number of experiments on quantities ranging from 0.06 to 0.28 gram of pyrophosphate the results were, with a few exceptions, naturally lower than those obtained on duplicates by the ordinary method of igniting, but only by 0.0013 gram in maximum.

Mastbaum, to shorten time, applies the full flame to the moist precipitate wrapped in its filter. Later, when most of the carbon is burned off, he moistens the residue with two or three drops of strong nitric acid, evaporates this carefully, heats with full burner for a few minutes, then blasts for half a minute. He describes the results as irreproachable. In this laboratory only the Mastbaum modification has been tried, and it certainly seems to be satisfactory when the extreme of accuracy is not required.

At one time the procedure first recommended by Ulbricht, later by Broockmann, and also by L. L. de Koninck, was used. It consists in dissolving the ammonium-magnesium phosphate off the filter with nitric acid, collecting the filtrate in a weighed crucible, evaporating the contents to dryness,[4] and subsequently igniting, the product being presumably pyrophosphate. But it was soon observed that the ignited salt, especially when large in amount, does not always dissolve com-

[1] Zeitschr. für anal. Chemie, Vol. XXXIII, p. 362, 1894.

[2] Ibid., Vol. XXXVII, p. 308, 1898.

[3] Ibid., p. 581, 1898.

[4] A pink color of varying intensity almost invariably becomes apparent as the mass approaches dryness, a most delicate test for the traces of manganese which always escape precipitation by ammonium sulphide or bromine.

pletely in hydrochloric acid, but that sometimes a white residue is left in light lumps which appears to be quite insoluble in acids. This residue contains no silica, but only the constituents of a magnesian phosphate, and it may be a peculiar metaphosphate. Whether its appearance is due to an abnormal composition of the original magnesian precipitate or to conceivable change during evaporation in the crucible with nitric acid remains to be determined. Until this is done the employment of this method of igniting is not to be recommended.

CONTAMINATION BY AND REMOVAL OF BARIUM AND CALCIUM.

Barium phosphate will not contaminate the second magnesian precipitate unless there are notable amounts of barium in the rock, in which case it must be removed by sulphuric acid prior to the final precipitation of the magnesium. Calcium, however, is probably never absent, and has to be estimated and allowed for as follows:

To the ignited pyrophosphate, dissolved in but slight excess of hydrochloric acid, is added ammonia to alkalinity, and then acetic acid, drop by drop, till the solution, which should not be hot, clears. It now and then happens that a little flocculent matter fails to dissolve. This is to be removed, ignited, and subtracted from the original weight. It is likely to consist, in great part or wholly, of phosphates of iron or manganese, or both, and shows often a reddish color on ignition. If an excess of acetic acid has been used, this is cautiously removed by ammonia. Then a drop or two of solution of ammonium oxalate is added, and the small beaker is set aside for twelve hours if necessary. Almost invariably a small precipitate soon shows itself, which if fine-grained and nonadherent to the glass may be regarded as pure calcium oxalate; otherwise it contains, or may largely consist of, magnesium oxalate. It is in that case to be collected, ignited, redissolved, and reprecipitated. Its final weight, averaging perhaps one-half milligram, is to be added to that of the lime already found, and subtracted as tricalcium phosphate from that of the magnesium pyrophosphate in order to arrive at the true figure for magnesia. This separation, to be satisfactory, requires great care.

XII. TITANIUM.

COLORIMETRIC ESTIMATION WITH HYDROGEN PEROXIDE (WELLER'S METHOD).[1]

The method consists in comparing the color of a known bulk of solution to be tested with that of a standard solution of titanium sulphate, both having been fully oxidized by hydrogen peroxide. The strength

[1] Ber. deutsch. chem. Gesell., Vol. XV, p. 2593, 1882.

of the peroxide should be approximately measured by titration with permanganate on opening a fresh bottle, and again after a few weeks, otherwise very serious error may arise through its deterioration.

Mere traces of hydrofluoric acid, either in the peroxide or the titanium solution, render this method inexact,[1] hence care should be exercised as to the character of the peroxide, which, as sold in the market, often contains fluorine.

Dunnington[2] has pointed out the necessity for the presence of at least 5 per cent of sulphuric acid in solutions which are to be thus tested for titanium, in order, as he concludes, to prevent partial reversion to metatitanic acid, which does not give a color with hydrogen peroxide. The standard solution of titanium sulphate, holding conveniently about 1 centigram TiO_2 in 10 cm.^{3}, equivalent to 1 per cent of TiO_2 in 1 gram of rock, contains, therefore, 5 per cent or more of sulphuric acid. Of this, 10 cm.^{3} are mixed with a sufficiency of hydrogen peroxide (2 cm.^{3} of most commercial brands is ample) and diluted to 100 cm.^{3} in a measuring flask.

Titanium can be estimated, as a rule, most conveniently in the solution which has served for the titration of total iron (p. 57). This, having been evaporated, if necessary, to less than 100 cm.^{3}, is to be fully oxidized with hydrogen peroxide, and if the color is less intense than that of the standard, is made up to 100 cm.^{3} with dilute sulphuric acid in a measuring flask, and mixed; otherwise, in a flask of sufficient size to insure that its color shall be less intense. One of the rectangular glasses described below being filled with the solution to be tested, 10 cm.^{3} of the diluted standard are run into the other from a burette, and water is added from a second burette until there is no distinction as to color. A second and a third portion of the standard can be run in and diluted and the mean of several determinations struck, when a simple calculation gives the percentage of TiO_2 in the rock.

If the convenient but expensive Soleil-Duboscq colorimeter is used, or the simple Nessler tubes, it is of course unnecessary to dilute the rock solution to the extent above required, should it be stronger than the standard. Experience has shown, however, that differences can not be sharply estimated in strongly colored solutions, and that the results are much more satisfactory when the color intensity is not much, if any, greater than that given by a standard of the above concentration. For the percentages of titanium found in rocks, clays, and soils, usually under 1 per cent, but rising to 2 or even 3 per cent or more occasionally, the colorimeter method gives results which are fully equal to those of the best gravimetric method, besides being a great time

[1] Hillebrand: Jour. Am. Chem. Soc., Vol. XVII, p. 718, 1895; Chemical News, Vol. LXXII, p. 158, 1895; Bull. U. S. Geol. Survey No. 167, p. 56.

[2] Jour. Am. Chem. Soc., Vol. XIII, p. 210, 1891.

saver. The error introduced by iron, in consequence of the yellowish color of its sulphate solution, is practically negligible unless its percentage is very high; then either the iron must be removed prior to making the color test, or correction should be applied for known amounts of ferric sulphate in solutions of the requisite dilution.

The exact correction to be applied in such cases is difficult of determination because of the impossibility of matching the colors of titanium peroxide solutions with those of ferric sulphate; but tests made go to show that the coloring effect of 0.1 gram of Fe_2O_3 in 100 cm.^{3} 5 per cent sulphuric-acid solution is about equal to 0.2 milligram of TiO_2 in 100 cm.^{3} when oxidized by hydrogen peroxide. This amounts to a correction of only 0.02 per cent on 1 gram of rock containing the unusual amounts of 10 per cent Fe_2O_3. It will be more satisfactory, when much iron is present, to remove this as described on page 71 and to colorimetrically estimate the titanium thus freed from iron.

ALTERNATIVE MODE OF PREPARING THE TEST SOLUTION.

As said above (pp. 57 and 68), the solution that has been used for volumetric estimation of total iron can most conveniently be used for the colorimetric determination of titanium, but if desired this can, of course, be made on some other portion of rock powder. At one time it was the practice in this laboratory to combine it with the determination of barium, as described in Bulletin 148 of the United States Geological Survey, by decomposing the powder by sulphuric and hydrofluoric acids,[1] expelling the latter by repeated evaporations with sulphuric acid, taking up with dilute sulphuric acid,[2] filtering from barium sulphate, etc., and estimating the titanium colorimetrically in the filtrate. The expulsion of fluorine must be thorough, or else the titanium result will be low, as already stated (p. 68), and it is not always easy to effect this complete removal, though the time required to do so seems to be in no slight degree dependent on the nature of the fluorides to be decomposed. Long after every trace of fluorine seems to be gone, the formation of a crust on the evaporating solution sometimes allows an accumulation of enough hydrofluoric-acid gas to become plainly manifest to the smell on breaking the crust.

[1] It is to be borne in mind that evaporation with hydrofluoric acid alone results in loss of titanium by volatilization, but that there is no loss if excess of sulphuric acid is also present.

[2] With acid rocks solution is very complete, and it can be made nearly so with the most basic by transference to a small beaker and gentle boiling. The residue thus obtained may contain, besides barium sulphate, a little calcium sulphate, zircon, andalusite, topaz, and possibly a trace of titanium in some form. It is therefore to be thoroughly fused with sodium carbonate, leached with water, fused with potassium bisulphate, dissolved in dilute sulphuric acid, filtered, and the filtrate added to the main one. The insoluble matter will now be chiefly barium sulphate, for the further treatment of which see page 74.

THE COLORIMETRIC APPARATUS AND ITS USE.

The glasses G (fig. 12) may be of square or rectangular section, 8 to 12 cm. high and 3 to 3½ cm. inside measurement between those sides through which the liquid is to be observed.[1] These sides should, of course, be exactly parallel; the others need not be, but should be blackened externally. In order to further exclude the effect of side

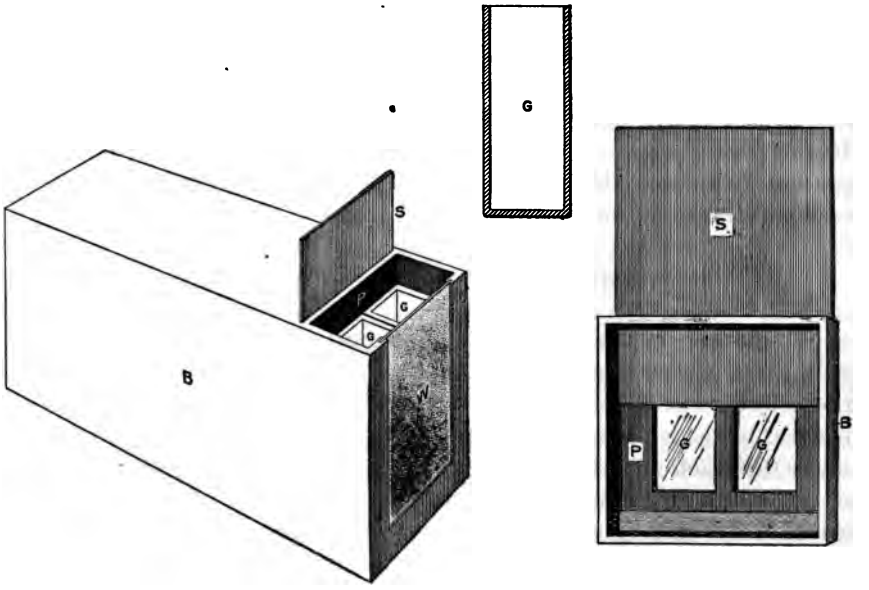

FIG. 12.—Apparatus for colorimetric determinations, in different aspects. G, one of two glasses of square or rectangular section, 8 to 12 cm. high and 3 to 3½ cm. inside measurement between those sides through which the liquid is to be observed. The other sides are blackened on the outside. B, rectangular box about 35 cm. long and 12 cm. square, stained black inside and out, one end closed by a ground-glass window, W, the other open, and a portion of the top removed. P, blackened partition, with openings corresponding to the interior dimensions of the glasses when in position. S, blackened cardboard shutter sliding stiffly up and down between partition and glasses, so as to shut off all light above the lowest surface of the liquid in the glasses.

light in this and other similar methods (chromium, for instance, p. 80), it is very convenient to have a simple light box (B, fig. 12) that can be easily held in one hand, about 35 cm. long and 12 cm. square, stained black inside and out and with one end closed by a piece of ground glass W, the other open. For a space equal to the width of the glasses the

[1] The allowable error in distance between the corresponding pairs of sides of the two glasses should not in any case exceed 1 per cent. Unfortunately there seems to be a disinclination or inability on the part of dealers in this country to furnish glasses fulfilling this requirement, and held together by a durable cement which shall be proof against dilute sulphuric acid. Canada balsam answers well for a time, but sooner or later it cracks, leaks then appear, and the sides soon drop off. It is, however, but a simple matter to cement them on again.

A pair of entirely satisfactory glasses can be made from a couple of square or rectangular 3 to 4 ounce bottles by cutting off one pair of sides from each and grinding down till the calipers show that *agreement is perfect.* The tops are then to be sawed off and pieces of plate glass cemented on the *sides.*

cover is removed at the top next the glass end to permit of the insertion of the glasses side by side in such a way that no light shall penetrate around their sides or between them. Immediately back of the glasses is a partition P, with openings of appropriate size cut in it. A stiffly sliding black cardboard shutter S is movable up and down immediately back of the partition, so that all light can be cut off except that which comes through the liquid.

Precautions of this kind are necessary if accurate results are to be counted on. Except for mere traces, this combination of glasses and darkened box insures greater accuracy and rapidity of work than Nessler tubes, and is preferable likewise, so far as the writer's experience goes, to expensive instruments like the colorimeter of Soleil-Duboscq, etc. In making the color comparisons the box is best held close to a window, so as to get a full, strong light. Daylight is far preferable to artificial light.

GOOCH'S GRAVIMETRIC METHOD.

When titanium is present in excess of 4 to 5 per cent and whenever for any reason it is desired to employ a gravimetric method, among the few that have been thoroughly tested that of Dr. Gooch[1] is unequaled. With one or two minor modifications introduced by Dr. T. M. Chatard,[2] it is as follows:

Any solution of the rock freed from silica can be used, and the first step is to remove the iron. This is best done, after adding tartaric acid and reducing the iron by means of hydrogen sulphide to the ferrous condition, by rendering the solution ammoniacal and introducing more hydrogen sulphide. If the iron is not thus reduced before precipitation, titanium will be in part thrown down also.[3] The amount of tartaric acid is to be gauged according to the combined weights of the oxides to be held by it in solution, and three times this weight is ample. After removing the iron sulphide by filtration—little washing suffices, because of the relatively small amount of titanium commonly present—the tartaric acid is destroyed as follows:

Potassium permanganate to the extent of two and one-half times the weight of the tartaric acid used is made into a strong solution, and to the ammoniacal filtrate from the iron sulphide enough sulphuric acid is introduced to leave some excess after all the permanganate has been reduced. After expulsion of hydrogen sulphide by boiling the permanganate is added gradually to the hot solution contained in a large beaker or flask. A vigorous reaction ensues. When a permanent brown precipitate of manganic hydrate appears the tartaric acid has

[1] Proc. Am. Acad. Arts Sci., n. s., Vol. XII, p. 435; Bull. U. S. Geol. Survey, No. 27, p. 16, 1886; Chemical News, Vol. LII, pp. 55 and 68, 1885.

[2] Am. Chem. Jour., Vol. XIII, p. 106, 1891; Bull. U. S. Geol. Survey, No. 78, p. 87; Chemical News, Vol. LXIII, p. 267, 1891.

[3] Cathrein: *Zeitschr., für Kryst.*, Vol. VI, p. 243, 1882; Vol. VII, p. 250, 1883.

been fully broken up, and the precipitated manganese is to be redissolved by a few drops of ammonium bisulphite or of sulphurous acid solution.

Ammonia is then added in slight excess, followed at once by acetic acid in considerable excess, and the boiling is continued for a few minutes. Thereby the titanium is freed from most of the alumina, and from lime and magnesia if they had not been earlier removed, also from most of the manganese introduced. The precipitate is filtered and washed with water containing acetic and sulphurous acids, then ignited, fused thoroughly with sodium carbonate, and leached with water to remove phosphoric acid and most of the remaining alumina. The residue is again ignited and fused with sodium carbonate. To the cooled melt in the crucible strong sulpuric acid is to be added, wherein it dissolves readily by aid of gentle heat. This solution is to be poured into a small volume of cold water and the platinum it contains precipitated by hydrogen sulphide at or near boiling temperature. After filtering and cooling, ammonia is added till the titanium is just precipitated, and a measured volume, containing a known weight of absolute sulphuric acid, is then added—just enough to redissolve the precipitate. The solution is then made up with acetic acid in such amount that the final bulk shall contain from 7 to 11 per cent of absolute acid, and then enough solid sodium acetate is stirred in to more than take up the sulphuric acid introduced. Upon rapidly bringing the liquid to ebullition the titanium is precipitated in flocculent and easily filterable condition, and the precipitation is complete after a minute's boiling, provided all the prescribed conditions have been followed and zirconium is absent.

The precipitate is washed first with acetic acid of 7 per cent strength and then with hot water. After 15 to 20 minutes' ignition over a good burner it is in condition for weighing and will lose no more weight over the blast lamp. For large amounts of titanium a repetition of the sodium carbonate fusion, etc., should be made. The actual carrying out of all these operations, when once the method is understood, requires much less time than the detailed description would indicate.

GOOCH'S METHOD NOT DIRECTLY APPLICABLE TO ROCKS CONTAINING ZIRCONIUM.

Prior to the adoption of the colorimetric method, Dr. Gooch's was invariably used in this laboratory. Occasional inability to secure clean and complete precipitation by it was experienced, especially with a certain series of rocks rather poor in titanium. Long research showed the difficulty to be due to the presence of zirconium, which acts as a marked preventive of the precipitation of titanium by boiling in an acetic acid solution under the conditions of the Gooch method.

The above rocks were found to contain up to 0.2 per cent of ZrO_2, and this amount was able to prevent precipitation of 0.3 per cent of

TiO_2. The titanium which came down in excess of this amount did not settle out in flocculent condition, as happens when zirconium is not present, and it was difficult to filter. After the removal of the zirconium in the manner to be hereafter described (p. 75), however, no difficulty was experienced in precipitating all the titanium with the usual case.

SUPERIORITY OF THE COLORIMETRIC AND GOOCH METHODS OVER THE OLDER ONES.

In view of the good results obtainable by the colorimeter method in all cases and by the Gooch method in the absence of zirconium, it is incomprehensible that the old method of precipitation by many hours' boiling in a nearly neutral sulphate solution in presence of sulphurous acid should still find adherents in any part of the world.

Attention has been directed (p. 60) to the error resulting from attempting to separate aluminum from titanium by either fused or dissolved sodium hydroxide.

BASKERVILLE'S METHOD.

Baskerville[1] has proposed the separation of titanium from iron and aluminum by boiling the neutralized solution of the chlorides for a few minutes in presence of sulphurous acid. The test separations as given by him are sharp, and a single precipitation is said to suffice, the titanium being free from iron and easily filterable. This last statement and the ready precipitability are fully confirmed by the experiments of the writer on titaniferous iron ores, but, although the titanium is completely thrown out, it carries with it a little iron, for instance, about 0.25 per cent Fe_2O_3 with 8 to 10 per cent TiO_2. Zirconium would probably be likewise precipitated (see p. 77) and phosphorus perhaps also, but this last point has not been investigated, neither has the applicability of the method to aluminous rocks been tested.

XIII. BARIUM (ZIRCONIUM, TOTAL SULPHUR).

Reasons for estimating barium in a separate portion of rock powder.— It has been said above (p. 63) that only in very exceptional cases will barium be found with the calcium and strontium after two, or possibly three, precipitations of the latter as oxalate, since it passes into the filtrates with the magnesium, whence it may be obtained as sulphate after removal of ammoniacal salts. Addition of some alcohol insures also the recovery of traces of strontium if the rocks are very rich in it. But it is unsafe to regard the amount thus separated from the magnesium as representing the total amount of barium in the rock. It

[1] Jour. Am. Chem. Soc., Vol. XVI, p. 427, 1894.

will almost always be found lower than the truth, probably for the reason that there are opportunities during the analysis for slight losses. It is best to estimate it in a separate 2-gram portion, which may also serve with advantage for the estimation of zirconium and total sulphur.

Modes of attack and subsequent treatment.—If zirconium and sulphur are not to be looked for, the simplest procedure is to decompose the powder by sulphuric and hydrofluoric acids (see p. 69, under Titanium), and to complete the purification of the barium sulphate thus obtained in the manner described in the third paragraph below.

If zirconium and sulphur are both to be likewise determined, decomposition is effected by fusing over the Bunsen flame and then over the blast with sulphur-free sodium carbonate and insufficient niter to injure the crucible, first fitting the latter snugly into a hole in asbestos board (Lunge) to prevent access of sulphur from the gas flame. In case sulphur is not to be regarded, the niter and asbestos board are omitted. After thorough disintegration of the melt in water, to which a drop or two of methyl or ethyl alcohol has been added for the purpose of reducing manganese, the solution is filtered and the residue washed with a very dilute solution of sodium carbonate free from bicarbonate. This is to prevent turbid washings. A yellow color in the filtrate indicates chromium.

For the further treatment of the filtrate see Sulphur, p. 106, and Chromium (colorimetric method), p. 80.

The residue is dissolved in quite dilute warm sulphuric acid (stronger acid may be used if barium only is sought) and filtered through the original filter. This, with its contents, is ignited, evaporated with hydrofluoric and sulphuric acid, and taken up with hot dilute sulphuric acid. The filtrate, added to the former one, now contains all the zirconium (see pp. 75–76 for its further treatment). The residue contains all the barium, besides some of the strontium, and perhaps a good deal of calcium. It is fused with sodium carbonate, leached with water, the residue dissolved off the filter by a few drops of hydrochloric acid, from which solution the barium is thrown out by a large excess of sulphuric acid. A single solution of the barium sulphate in concentrated sulphuric acid and reprecipitation by water suffices to remove traces of calcium which might contaminate it if the rock was one rich in calcium, and even strontium is seldom retained by it in quantity sufficient to give concern. Should this be the case, however, which will occur when the SrO and BaO are together in the rock in, roughly speaking, 0.2 and 0.4 per cent, respectively, the only satisfactory way is to convert the sulphates into chlorides and to apply to the mixture the ammonium-chromate method of separation (p. 63).

Barium and strontium sulphates can be brought into a condition for testing spectroscopically by reducing for a very few moments the whole or part of the precipitate on a platinum wire in the luminous

tip of a Bunsen burner, and then moistening with hydrochloric acid. This should be known to everyone, but probably is not.

The procedure outlined in the foregoing paragraphs for the estimation of calcium, strontium, and barium in silicate rocks is the one which long experience has shown to be best adapted for securing the most satisfactory results with a minimum expenditure of time.[1] Even where no attempt is made to separate contaminating traces of SrO and BaO one from the other, the error is usually of no great consequence, for an absolute error of 25 per cent, even, in a substance constituting only one or two tenths per cent of a rock is ordinarily of small moment compared with the ability to certify to its presence with approximate correctness.

With such small amounts of barium as are usually found in rocks it is doubtful if Mar's[2] method for the separation of barium from calcium and magnesium, by the solvent action of concentrated hydrochloric acid mixed with 10 per cent of ether on the chlorides, could be conveniently applied here, although for larger amounts the method would seem to be accurate and easily executed. Moreover, it would probably not entirely remove contaminating strontium, and hence offers no advantage.

XIV. ZIRCONIUM.

This element is rarely looked for by chemists, though shown by the microscope to be one of the most constant rock constituents, usually in the form of zircon, in which occurrence its amount can be approximately judged of and a chemical test rendered almost unnecessary; but sometimes it occurs in other minerals, and is then unrecognizable under the microscope. It may rarely be present up to a few tenths of 1 per cent of the rock.

AUTHOR'S METHOD.

For its detection and estimation in such cases, or whenever a search for it seems called for, the following procedure, based on a method by G. H. Bailey,[3] has been devised, which serves, when carried out with care, to detect with certainty the merest trace—0.02 per cent, for instance—in 1 gram.

The preliminary treatment of the rock powder has been fully given under Barium (p. 74), where the separation from barium has been described and also the concentration of the zirconia in a small amount of very dilute sulphuric solution. This should probably not contain much above 1 per cent of sulphuric acid, though the actually permissible limit has not been established. To the solution, which

[1] For details consult W. F. Hillebrand: Jour. Am. Chem. Soc., Vol. XVI, p. 83, 1894; Chemical News, Vol. LXIX, p. 147, 1894.

[2] Am. Jour. Sci., 3d ser., Vol. XLIII, p. 521, 1892.

[3] Jour. Chem. Soc., Vol. XLIX, pp. 149, 481, 1886.

should be in a small flask, is now added hydrogen peroxide to oxidize the titanium, and then a few drops of a soluble orthophosphate solution. The flask is set aside in the cold for twenty-four to forty-eight hours. If the color bleaches after a time, more hydrogen peroxide should be added. Under these circumstances the zirconium is thrown out as phosphate and collects as a flocculent precipitate, which at this stage is not always pure. No matter how small or insignificant, it is collected on a filter, ignited, fused with sodium carbonate, leached with water, the filter again ignited, fused with very little acid potassium sulphate, brought into solution in hot water with a few drops of dilute sulphuric acid, poured into a flask of about 20 cm.^{3} capacity, a few drops of hydrogen peroxide and of sodium phosphate added, and the flask set aside. Titanium is now almost never present, and the zirconium appears after a time as a white flocculent precipitate, which can be collected and weighed as phosphate. For the small amounts usually met with it is safe to assume that it contains 50 per cent of ZrO_2 (51.8 by theory). If the amount is rather large, it may be fused with sodium carbonate, leached, ignited, fused with acid potassium sulphate, reprecipitated by ammonia, and weighed as ZrO_2. Certainty as to its identity can be had by again bringing it into solution, precipitating by ammonia, dissolving in hydrochloric acid, evaporating to a drop or two, and testing with turmeric paper or by a microchemical reaction. With the very smallest amounts no color can be obtained by this turmeric-paper test, which, however, responds readily to as little as 1 milligram of dioxide and with proper care for as small an amount as 0.3 milligram (Dr. H. N. Stokes). No element other than thorium is ever likely to contaminate the zirconium thus precipitated.

In Bailey's experiments the precipitation was not made by addition of a phosphate, but is said to be due solely to the hydrogen peroxide, the precipitate being a hydrated peroxide, Zr_2O_5, or ZrO_3.[1] My own efforts to secure a precipitate in acid solutions of zirconium sulphate by hydrogen peroxide alone were unsuccessful, perhaps for lack of a sufficiently strong peroxide. The ability to obtain the zirconium free from phosphoric acid would certainly be a great improvement on the method described above.

Were it not for the necessity of working in a weakly acid solution, the separation of zirconium could be made in the same portion in which the titanium is colorimetrically determined.

OTHER METHODS OF SEPARATING ZIRCONIUM.

Streit and Franz[2] claim to secure complete separation of titanium from iron and zirconium by boiling the neutralized solutions of the

[1] Bailey, Chemical News, Vol. LX, p. 6, 1889.
[2] Jour. für prakt. Chemie, Vol. CVIII, p. 65, 1869.

sulphates with a large excess (50 per cent) of acetic acid. The method has been from time to time recommended, but without any data showing its value. The single separation made by Streit and Franz was far from perfect.

Davis[1] separated zirconium sharply from aluminum, but not from iron, by precipitation as an oxyiodate in a boiling neutralized solution of chlorides, but the method is hardly applicable for rock analysis.

Baskerville[2] has proposed a method for the separation of zirconium from iron and aluminum similar to his method for the separation of titanium from those elements (p. 73). It is based on the precipitability of ZrO_2 by boiling the neutralized chloride solution for two minutes in presence of sulphurous acid, and seems to be excellent. As titanium is always present and is presumably quantitatively thrown down also, the two would have to be separated by hydrogen peroxide. No tests as to the availability of the method for separating the small amounts met with in rock analysis have been made.

XV. RARE EARTHS OTHER THAN ZIRCONIA.

For the few cases in which it may be necessary to look for rare earths other than zirconia, the following procedure is suggested as likely to prove satisfactory.

The rock powder is thoroughly decomposed by several partial evaporations with hydrofluoric acid, the fluorides of all earth metals except zirconium are collected on a platinum cone, washed with water acidulated by hydrofluoric acid, and the precipitate washed back into the dish or crucible and evaporated with enough sulphuric acid to expel all fluorine. The filter is burned and added. By careful heating the excess of sulphuric acid is removed and the sulphates are taken up by dilute hydrochloric acid. The rare earths, with perhaps some alumina, are then separated by ammonia, washed, redissolved in hydrochloric acid, and evaporated to dryness, then taken up with water and a drop of hydrochloric acid, and only enough ammonium acetate to neutralize the latter added, followed by oxalic acid (not ammonium oxalate, which would fail to precipitate thorium). In this way as little as 0.03 per cent of rare earths have been found when working on not more than 2 grams of materials.

This method eliminates at once most of the aluminum, all the iron, phosphorus, titanium, and zirconium, and has the further advantage of collecting with the earthy fluorides, as UF_4, any uranous uranium that the rock might have held.

An alternative method would be to fuse with sodium carbonate, leach with water to get rid of phosphorus as far as possible, dissolve the

[1] Am. Chem. Jour., Vol. XI, p. 27, 1889.

[2] *Jour. Am. Chem. Soc.*, Vol. XVI, p. 475, 1894; Chemical News, Vol. LXX, p. 51, 1894.

residue in hydrochloric acid, separate silica as usual, precipitate alumina, etc., by ammonia, dissolve the precipitate again in hydrochloric acid, evaporate, and proceed as by the former method, which in most cases would undoubtedly give better results than this one.

XVI. PHOSPHORUS.

It is sometimes possible to extract all phosphorus from a rock by simple digestion with nitric acid, but quite as often, if not oftener, this fails; hence the necessity for resorting to one of the longer methods of extraction detailed below.

PROCEDURE WHEN MATERIAL IS AMPLE.

When material is ample it is best to use one portion for phosphorus only and to proceed as follows:

Fuse with sodium carbonate, separate silica by a single evaporation with nitric acid, treat the ignited silica with hydrofluoric and a drop or two of sulphuric acids, evaporate to expel hydrofluoric acid, bring the small residue into solution by boiling with nitric acid and add it to the main portion, in which, after addition of considerable ammonium nitrate, precipitate the phosphorus by molybdate solution.

The turbidity often observed on dissolving the precipitated and washed phospho-molybdate in ammonia is due to a compound of phosphorus. If the addition of a small fragment of a crystal of citric or tartaric acid fails to dissolve it, this should always be re-fused with sodium carbonate, extracted with water and the filtrate otherwise treated as above, in order to secure the phosphorus in it.

According to Gooch and Austin,[1] in order to secure a magnesium-ammonium phosphate of normal composition, the procedure at this point should be as follows: To the phosphate solution, containing not more than 5 to 10 per cent of ammonium chloride and a slight excess of magnesia mixture, a little ammonia is added, and the precipitate is washed in due time with weak ammonia water. In general, however, as these conditions can seldom be fulfilled, they recommend to decant the supernatant liquid through the filter which is later to receive the precipitate, to dissolve this in as little hydrochloric acid as possible, to reprecipitate by dilute ammonia without further addition of magnesia mixture, and to wash finally with weakly ammoniacal water. Excess of ammonia, of ammonium salts, and of precipitant are all objectionable. In rock analysis the second precipitation will seldom be necessary. For ignition, etc., of the precipitate, see this subject under Magnesium (p. 66.)

[1] Am. Jour. Sci., 4th series, Vol. VII, p. 187, 1899; Zeitschr. für anorg. Chemie, Vol XX, p. 121, 1899; Chemical News, Vol. LXXIX, pp. 233, 244, 255, 1899.

PROCEDURE WHEN MATERIAL IS SCANTY.

The following procedure admits of determining in the same portion, besides phosphorus, barium, iron, vanadium, chromium, and titanium, the last two either colorimetrically or gravimetrically, and is in large part extracted from a paper by Dr. T. M. Chatard.[1]

Silica is removed by hydrofluoric and sulphuric acids, excess of fluorine expelled, the residue brought into solution as far as possible with sulphuric or hydrochloric acid and hot water, filtered, the residue ignited, fused with sodium carbonate, dissolved in hydrochloric acid, and the solution, after precipitation of barium, added to the main one, which is now precipitated by ammonia to get rid of the magnesium salts usually present and thus insure a cleaner subsequent fusion with sodium carbonate.

The precipated Al_2O_3, P_2O_5, Cr_2O_3, Fe_2O_3, and TiO_2 is dissolved in hot hydrochloric acid and filtered into a large platinum crucible, the filter burned and added, the solution evaporated to pastiness, a little water added to dissolve the salts, and dry sodium carbonate added in portions and stirred in thoroughly to prevent lumpiness in the fusion to follow, which is continued for half an hour. Addition of sodium nitrate is not necessary.

The fused mass is boiled out with water and washed with very dilute sodium-carbonate solution. In the residue iron and titanium can be determined by the methods already described. In the filtrate chromium can be determined colorimetrically if present in sufficient amount to give a pronounced color (see p. 80). Afterwards, or immediately if the chromium is not to be thus estimated, enough ammonium nitrate is added to react with all the carbonate and the solution is digested on the bath till most of the ammonium carbonate is gone. Nearly, if not quite all alumina is thus thrown out, carrying with it all phosphorus. The precipitate is washed with dilute ammonium-nitrate solution till the yellow color wholly disappears, after which it is dissolved in nitric acid and the phosphorus thrown out by molybdate solution. The filtrate, containing chromium and vanadium, can be treated as detailed in the next following sections.

XVII. CHROMIUM.

If vanadium is absent, or nearly so, as is apt to be the case in those highly magnesian rocks (peridotites) usually carrying a good deal of chromium, the following separation and gravimetric method for chromium gives good and concordant results, but in presence of vanadium, and it is best generally to assume its presence, the colorimetric method should always be adopted.

[1] Am. Chem. Jour. Vol. XIII, p. 106, 1891; Bull. U. S. Geol. Survey No. 78, p. 87; Chemical News, Vol. LXIII, p. 267, 1891.

GRAVIMETRIC METHOD.

Having obtained chromium in solution as chromate and free from all else but a little alumina, as at the conclusion of the preceding section on phosphorus, proceed as follows:

Concentrate if necessary and add fresh ammonium sulphide, or introduce hydrogen sulphide. The chromium is reduced and appears as a precipitate of sesquioxide mixed with the rest of the alumina. This precipitate is now treated according to Baubigny[1] by dissolving in nitric acid, evaporating to near dryness and heating with strong nitric acid and potassium chlorate, finally evaporating to dryness to get rid of the acid. Oxidation is complete and very speedy. On dilution with cold water, acid sodium carbonate is added in slight excess, and after two or three hours the precipitated alumina is filtered off. From the filtrate the chromium is then thrown out by fresh ammonium sulphide, redissolved and reprecipitated to free from alkali, and weighed.

The separation of aluminum from chromium by hydrogen peroxide in ammoniacal solution, as recommended by Jannasch and Cloedt,[2] has been shown by Friedheim and Brühl,[3] together with most of the other separations of Jannasch based on the use of hydrogen peroxide and from which so much was hoped, to be valueless.

COLORIMETRIC METHOD.

For this very accurate and by far the quickest method[4] for determining chromium in rocks and ores where the amount does not exceed a few per cent, there is needed the aqueous extract of a sodium-carbonate fusion of the rock (as obtained, for instance, under Phosphorus, p. 79) in order to compare its color with that of a standard solution.

Preparation and strength of standard solution.—This standard solution is made by dissolving 0.25525 gram or double that amount of pure potassium monochromate in one liter of water made alkaline by a little sodium carbonate. Each cubic centimeter then corresponds to one-tenth milligram or two-tenths milligram of chromic oxide (Cr_2O_3), in which condition chromium is usually reported in rocks and ores. It is probably inadmissible to increase the strength of the standard much above the figure given.

Preparation of the test solution.—Before filtering the aqueous extract of the sodium-carbonate fusion a few drops of alcohol (ethyl or methyl) are added to destroy the color of sodium manganate. If the yellow color of the filtrate is very faint, concentration by evaporation

[1] Bull. Soc. Chimique (n. s.) Vol. XLII, p. 291, 1884; Chemical News, Vol. L, p. 18, 1885.

[2] Zeitschr. für anorg. Chemie, Vol. X, p. 402, 1895.

[3] Zeitschr. für anal. Chemie, Vol. XXXVIII, p. 681, 1899.

[4] W. F. Hillebrand, Jour. Am. Chem. Soc., Vol. XX, p. 454, 1898; Chemical News, Vol. LXXVIII, pp. 227, 239, 1898; Bull. U. S. Geol. Survey No. 167, p. 37; First applied by L. de Koningh (Nederl. Tyds. voor Pharm. Chem. and Tox., 1889) for the estimation of chromium in foodstuffs.

will strengthen it, and less than 2 milligrams of chromic oxide in 1 gram of rock can then be exactly measured. For smaller amounts it is best to employ from 3 to 5 grams of powder and then to concentrate the chromium by precipitation by mercurous nitrate, as detailed in the next section under Vanadium (p. 83); otherwise it may be difficult or impossible, because of the large amount of alkali carbonate present, to obtain a filtrate of sufficiently small bulk to show a decided color.

If niter has been used in the fusion and the crucible has been at all attacked by it, a yellow coloration of the filtrate may be due to dissolved platinum, but neither the proportion of niter nor the temperature of the blast should ever be high enough to permit the crucible to be attacked.

Comparison of colors.—The final solution is transferred to a graduated flask of such size that its color shall be weaker than that of the standard chromium solution. Definite amounts of the latter are then diluted with water from a burette until of the same strength as the test solution, exactly as described on page 68 for the colorimetric estimation of titanium. For very minute amounts it is necessary to use Nessler tubes, as in ammonia estimations, instead of the glasses and apparatus described and depicted under Titanium (p. 70).

As with colorimetric methods in general, this one gives better results with small than with large percentages of chromium, yet it can be applied in the latter cases with satisfactory results by making a larger number of consecutive comparisons with the same solution.

A FEW COMPARATIVE DATA.

A few comparisons between colorimetric and gravimetric determinations of chromium are here given to show the order of agreement, the former having been made several months and even years after the latter.

Gravimetric per cent Cr_2O_3.	Colorimetric per cent Cr_2O_3.
Trace.	0.018
0.05	.051
.14	.12
.08	.033
Trace.	.013
None.	.0086
None.	.0067

The outcome was somewhat surprising, for it was hardly to be expected that the long and laborious quantitative separations should

have resulted so well as they are shown to have done. It should be mentioned that for the gravimetric tests but one or two grams at most were used, which accounts for the reported absence of chromium in two instances, this report being based on the lack of color in the aqueous extract of the alkali fusion after removal of manganese.

XVIII. VANADIUM (CHROMIUM) AND MOLYBDENUM.

DISTRIBUTION OF VANADIUM AND MOLYBDENUM.

The wide distribution of vanadium thoughout the earth's crust has in recent years been clearly established (see ante, p. 18), not only in ores and in coals, but in clays, limestones, sandstones, and igneous rocks.[1] The writer has shown (loc. cit.) that vanadium occurs in quite appreciable amounts in the more basic igneous and metamorphic rocks up to 0.08 per cent or more of V_2O_3, but that it seems to be absent, or nearly so, from the highly siliceous ones. Some of their ferric aluminous silicate constituents carry still higher percentages—up to 0.13 per cent V_2O_3 in a biotite separated from a pyroxenic gneiss. Molybdenum, on the other hand, appears to be confined in quantities susceptible of detection to the more siliceous rocks, and, except perhaps in rare instances, is not present in them in quantitatively determinable amount when operating on 5 grams of material. Hence the quantitative search for vanadium will usually be limited to rocks with less than 60 per cent of silica. The search for it even then will perhaps not often warrant the necessary expenditure of time, but in this connection it is to be remembered that neglect to estimate it introduces an error in the figures for both ferrous and ferric oxides, which in extreme cases met with may be of considerable moment. (See p. 58, and also pp. 95–96.)

DESCRIPTION OF METHOD.

In the following method there is nothing absolutely novel except that chromium and vanadium, when together, need not be separated, but are determined, the former colorimetrically, as already described (p. 80), the latter volumetrically, in the same solution.[2]

Five grams of the rock are thoroughly fused over the blast with 20 of sodium carbonate and 3 of sodium nitrate. After extracting with water and reducing manganese with alcohol it is probably quite unnecessary, if the fusion has been thorough, to remelt the residue

[1] W. F. Hillebrand, Distribution and quantitative occurrence of vanadium and molybdenum in rocks of the United States: Am. Jour. Sci., 4th series, Vol. VI, p. 209, 1898; Chemical News, Vol. LXXVIII, p. 216, 1898; Bull. U. S. Geol. Survey No. 167, p. 49.

[2] W. F. Hillebrand: Jour. Am. Chem. Soc., Vol. XX, p. 461, 1898; Chemical News, Vol. LXXVIII, p. 295, 1898; Bull. U. S. Geol. Surv., No. 167, p. 44.

as above, though for some magnetites and other ores containing larger amounts of vanadium than the generality of rocks, this may be necessary, as Edo Claassen has shown.[1] The aqueous extract is next nearly neutralized by nitric acid, the amount to be used having been conveniently ascertained by a blank test with exactly 20 grams of sodium carbonate, etc., and the solution is evaporated to approximate dryness. Care should be taken to avoid overrunning neutrality, because of the reducing action of the nitrous acid set free from the nitrite produced during fusion, but when chromium is present it has been my experience that some of this will invariably be retained by the precipitated silica and alumina, though only in one case have I observed a retention of vanadium, it being then large. The use of ammonium nitrate instead of nitric acid for converting the sodium carbonate into nitrate does not seem to lessen the amount of chromium retained by the silica and alumina.

As a precautionary measure, therefore, and always when chromium is to be estimated also, the silica and alumina precipitate should be evaporated with hydrofluoric and sulphuric acids, the residue fused with a little sodium carbonate and the aqueous extract again nearly neutralized with nitric acid and boiled for a few moments, the filtrate being added to the main one.

Mercurous nitrate is now added to the cold alkaline solution in some quantity, so as to obtain a precipitate of considerable bulk, containing, besides mercurous carbonate, chromium, vanadium, molybdenum, tungsten, phosphorus, and arsenic, should all happen to be in the rock. The mercurous carbonate serves to counteract any acidity resulting from the decomposition of the mercurous nitrate. Precipitating in a slightly alkaline instead of a neutral solution, renders the addition of precipitated mercuric oxide unnecessary for correcting this acidity. If the alkalinity, as shown by the formation of an unduly large precipitate, should have been too great, it may be reduced by careful addition of nitric acid until an added drop of mercurous nitrate no longer produces a cloud.

After heating and filtering, the precipitate is ignited in a platinum crucible, after drying and removing from the paper to obviate any chance of loss of molybdenum and of injury to the crucible by reduction of arsenic. The residue is fused with a very little sodium carbonate, leached with water, and the solution, if colored yellow, filtered into a graduated flask of 25 or more cubic centimeters capacity. The chromium is then estimated accurately in a few minutes by comparing with a standard alkaline solution of potassium monochromate (p. 80). Then, or earlier in absence of chromium, sulphuric acid is added in slight excess and molybdenum and arsenic, together with occasional traces of platinum, are precipitated by hydrogen sulphide, preferably

[1] Am. Chem. Jour., Vol. VIII, p. 437, 1886.

in a small pressure bottle.[1] If the color of the precipitate indicates absence of arsenic the filter with its contents is carefully ignited in porcelain, and the delicate sulphuric-acid test for molybdenum is applied as follows: The molybdenum compound is heated in porcelain with a single drop of strong sulphuric acid till the acid is nearly volatilized. On cooling a beautiful blue color is proof of the presence of molybdenum.

The filtrate, in bulk from 25 cm.^{3} to 100 cm.^{3} is boiled to expel hydrogen sulphide, and titrated at a temperature of 70° to 80° C. with a very dilute solution of permanganate representing about 1 mg. of V_2O_5 per cubic centimeter as calculated from the iron strength of the permanganate, one molecule of V_2O_5 being indicated for each one of Fe_2O_3. One or two checks are always to be made by reducing again by means of a current of sulphur dioxide gas, boiling this out again,[2] and repeating the titration. The latter results are apt to be a very little lower than the first and are to be taken as the correct ones.

In case the volume of permanganate used is so small as to make doubtful the presence of vanadium, it is necessary to apply a qualitative test, which is best made as follows: The solution is evaporated and heated to expel excess of sulphuric acid, the residue is taken up with two or three cubic centimeters of water and a few drops of dilute nitric acid, and a couple of drops of hydrogen peroxide are added. A characteristic brownish tint indicates vanadium. Unless the greater part of the free sulphuric acid has been removed the appearance of this color is sometimes not immediate and pronounced, hence the above precaution. It is also necessary that the nitric acid shall be in considerable excess, since in a neutral or only faintly acid solution the color does not appear strongly.

The above is a surer test to apply than the following: Reduce the bulk to about 10 cubic centimeters, add ammonia in excess and introduce hydrogen sulphide to saturation. The beautiful cherry-red color of vanadium in ammonium-sulphide solution is much more intense than that caused by hydrogen peroxide in acid solution, but the action of ammonia is to precipitate part or all of the vanadium with the chromium or aluminum that may be present or with the manganese used in titrating, and ammonium sulphide is unable to extract the vanadium wholly from these combinations. Usually, however, the

[1] From a sulphuric solution the separation of platinum and molybdenum by hydrogen sulphide is much more rapid and satisfactory than from a hydrochloric solution.

[2] The direct use of a solution of sulphur dioxide or of an alkali sulphite is inadmissible unless these have been freshly prepared, since after a lapse of time they contain other oxidizable bodies than sulphurous acid or a sulphite. The sulphur dioxide is best obtained as wanted by heating a flask containing a solution of sulphur dioxide, or of a sulphite to which sulphuric acid has been added.

The expulsion of the last traces of sulphur dioxide is said to be more effectively accomplished by boiling with simultaneous passage of a rapid current of carbon dioxide for a few minutes at the last than by boiling alone. Because of the small amount of air carried with it, long passage of the gas is said to result in slight oxidation of the vanadium (Manasse, Ann. Chem. u. Pharm., Vol. CCXL, p. 23, 1887; Zeitschr. für anal. Chemie, Vol. XXXII, p. 225, 1893).

solution will show some coloration, and addition of an acid precipitates brown vanadium sulphide, which can be collected, ignited, and further tested if desired.

APPLICATION OF THE METHOD IN PRESENCE OF RELATIVELY MUCH CHROMIUM.

The application of the method in its foregoing simplest form is subject to one limitation—the chromium must not be present above a certain moderate amount. This limitation is due to the considerable amount of permanganate then required to produce a clear transition tint when titrating in a hot solution, as is advisable with vanadium. In a cold solution of chromic sulphate much less permanganate is needed to produce the peculiar blackish tint without a shade of green, which affords a sure indication of excess of permanganate, but in a hot and especially a boiling solution the oxidation of the chromium itself takes place so rapidly that a very large excess of the reagent may be added before a pronounced end reaction is obtained. Nevertheless, quite satisfactory determinations of as little as one or two milligrams of vanadium pentoxide can be made in presence of as much as 30 milligrams of chromic oxide. To accomplish this it is only necessary to apply a simple correction obtained by adding permanganate to a like bulk of equally hot chromic sulphate solution containing approximately the same amount of chromium.

Ridsdale[1] titrated the cold solution to avoid oxidation of chromium, and obtained accurate results, but in the writer's experience the end reaction is then uncertain.

[1] Jour. Chem. Soc., Vol. VII, p. 73, 1888.

The following tables contain the results of a considerable numbe of tests, those in Table II being tabulated separately in order to sho the degree of accuracy attainable with a large excess of chromium b applying the correction above mentioned and also the amount of th correction:

TABLE I.

Tests for vanadium in the presence of chromium.

No.	Chromic oxide.	Vanadium pentoxide.	Vanadium pentoxide found.	Error.
	Milligrams.	*Milligrams.*	*Milligrams.*	*Milligram.*
1	1	9.87	9.22	−0.15
2	1	.94	1.04	+ .10
			.98	+ .04
3	1.5	5.25	5.49	+ .24
			5.43	+ .19
4	2	5.62	5.5	− .12
			5.5	− .12
5	3	4.68	4.78	+ .10
			4.78	+ .10
			4.83	+ .15
6	3	5.62	5.58	− .04
			5.58	− .04
7	3.5	18.74	18.89	+ .15
			18.97	+ .23
8	6	5.6	6.1	+ .50
9	6	4.68	4.78	+ .10
10	6	5.62	5.58	− .04
11	10	5.62	5.58	− .04
12	10	23.52	23.81	+ .29
			23.71	+ .19
13	10	46.85	46.98	+ .13
			47.20	+ .35
14	25	23.52	23.65	+ .13
			23.75	+ .23
15	87.5	23.52	23.71	+ .19

TABLE II.

Showing application of correction for larger amounts of chromium, obtained by adding potassium permanganate to an equal bulk of solution containing a like amount of chromic sulphate.

No.	Chromic oxide.	Vanadium pentoxide.	Vanadium pentoxide found.	Vanadium pentoxide found.	Error.	Volume of solution.
	Milligrams.	*Milligrams.*	*Uncorrected.*	*Corrected.*	*Milligram.*	
16	20	0.94	1.59	0.99	+0.05	50–100 cm.³
17	20	1.87	2.69	2.09	+ .22	50–100 cm.³
			2.39	1.79	− .08	
			2.59	1.99	+ .12	
18	20	18.74	19.4	18.73	− .01	50–100 cm.³
			19.3	18.63	− .11	
			19.3	18.63	− .11	
19	30	1.87	2.99	2.14	+ .27	About 100 cm.³
			2.79	1.94	+ .07	
			2.79	1.94	+ .07	
			2.69	1.84	− .03	
			2.69	1.84	− .03	
20	30	1.87	2.69	1.79	− .08	200 cm.³
			2.89	2.09	+ .22	
			2.89	2.09	+ .22	
			2.79	1.99	+ .12	
21	62	46.85	48.60	47.60	+ .75	200 cm.³

In spite of the fact that the correction in most of the trials of this last table represents a large proportion of the permanganate used, the results must be considered satisfactory in view of the small amount of vanadium present, and they show that the method in competent hands after a little experience affords trustworthy figures.

The method of T. Fischer[1]—digestion of the precipitated lead salts with a strong solution of potassium carbonate—appears to offer the long-needed satisfactory quantitative separation of arsenic, phosphorus, chromium, tungsten, and molybdenum from vanadium, the normal lead meta-vanadate remaining quite unattacked, according to the author, while the other lead salts are wholly decomposed, but the applicability of this method to the separation of the minute amounts often found in rocks and ores has not been tested. The object has been in the present case to reach satisfactory results with the greatest expedition, and when chromium is not present in considerable amount this is accomplished.

Fortunately, chromium is almost never a prominent constituent of

[1] Inaugural Dissertation, Rostock, 1894.

clays, coals, iron ores, and those rocks in which vanadium has thus far been reported, for although it is usually certain of the most basic of the silicate rocks that are highest in chromium—as the peridotites—yet in these, so far as present experience teaches, vanadium is lacking, a fact doubtless connected with the simultaneous absence from them of ferric-aluminous silicates.

CONDITION OF VANADIUM IN ROCKS.

The above and elsewhere mentioned connection of vanadium with the ferric-aluminous silicates of rocks, taken in connection with the existence of the mineral roscoelite, classed as a vanadium mica, indicates a condition of the vanadium corresponding to aluminum and ferric iron, and that it is to be regarded as replacing one or both of these elements. Hence it should be reported as V_2O_3 and not as V_2O_5.

What its condition may be in matter of secondary origin, like clays, limestones, sandstones, coals, and ores of iron, is yet open to discussion. It was the writer's opinion until recently, that it should then be regarded as in the pentavalent state (V_2O_5), but his work upon certain remarkable vanadiferous sandstones[1] of western Colorado, in which it unquestionably occurs as trivalent vanadium (V_2O_3), has led to a decided unsettling of this view. It is but proper to recall that Czudnowicz,[2] because of the extreme difficulty in completely extracting it from iron ores by an alkali-carbonate fusion and because of the easy reducibility of vanadic acid by ferrous salts, under the conditions in which brown iron ores are supposed to form, considered the vanadium in such ores to be in a lower condition of oxidation (V_2O_3). Lindemann's[3] contrary conclusion with regard to certain iron ores, because the vanadium was extracted as V_2O_5 by sodium-carbonate fusion without niter, is not valid, since this would probably be the case even if it existed in the ore as V_2O_3.

XIX. FERROUS IRON.

COMPARISON OF SEALED-TUBE AND HYDROFLUORIC-ACID METHODS—COMPARATIVE WORTHLESSNESS OF THE FORMER IN ROCK ANALYSIS.

No point in rock analysis has been the cause of greater solicitude to the chemist, and especially to the mineralogist and petrographer, than the determination of iron in ferrous condition. The sealed-tube or Mitscherlich method with sulphuric acid, for a long time the only available one, is in theory perfect, since complete exclusion of oxygen is easily attainable. Its chief hitherto recognized defect lies in the inability to always secure complete decomposition of the iron-bearing minerals, and even to ascertain, oftentimes, whether or not the decom-

[1] Hillebrand and Ransome: Am. Jour. Sci., 4th series, Vol. X, p. 120, 1900.
[2] Pogg. Ann., Vol. CXX, p. 20, 1863.
[3] *Dissertation, Jena.* 1878, through Zeitsch. für anal. Chemie, Vol. XVIII, p. 99, 1879.

position has been complete. The addition of hydrofluoric acid to the sulphuric in the tube, in order to insure this breaking up, is to be regarded as of very doubtful utility in most cases, since the glass may be so strongly attacked as to add an appreciable amount of iron to the solution, and the hydrofluoric acid may have exhausted itself in attacking the glass before the more refractory minerals succumb. Nevertheless, if decomposition can be effected by sulphuric acid alone the results obtained are sharp and concordant, and what has seemed especially remarkable, and up to almost the present moment without a satisfactory explanation, they are in rock analysis usually higher than when made by any of the modifications of the hydrofluoric-acid method now so extensively practiced. This difference is not very marked with rocks containing but 1 or 2 per cent of ferrous iron, but it increases with rising percentage to such an extent that where the sealed-tube method will show 12 per cent FeO the other may indicate no more than 10 per cent. This is a fact of which the writer has long been cognizant, but it does not seem to be known to chemists or petrographers at large, though Wülfing[1] has noticed this difference in certain analyses without appreciating its significance. Experiments with soluble iron salts of known composition, like ferrous sulphate and ferrous-ammonium sulphate, throw no light on the subject, for both methods give with them the same sharp and accurate results.

In spite of several attempts to find a solution to the problem, none presented itself until very recently, when, as a result of observations made in this laboratory by Dr. H. N. Stokes in a pending investigation on the action of ferric salts on pyrite and other sulphides, the clue was given. Dr. Stokes found that ferric salts exercise a most marked oxidizing effect on pyrite and probably other sulphides. The reaction is not new (see J. H. L. Vogt in Zeitschr. für prakt. Geol., 1899, pp. 250–251), but the ease with which the change takes place and the completeness of the oxidation of the pyrite, not only of its iron but of the greater part of the sulphur as well, were entirely unexpected. Pure pyrite itself is attacked with extreme slowness by boiling dilute sulphuric and hydrofluoric acids, either alone or mixed, but the moment a ferric salt is introduced the case is altogether different.

However, experiment has shown (p. 95) that with the amounts of sulphides usually found in igneous rocks their effect upon the estimation of ferrous iron by the hydrofluoric-acid method at atmospheric pressure and boiling heat is negligible, though by increasing the amount of sulphide the effect becomes more and more apparent, because of the greater surface of pyrite exposed to the action of the ferric iron of the rock.

Under the conditions of the Mitscherlich method, on the other hand—a temperature of 150 to 200° C., and even higher, high pressure, much longer time of action, and impossibility of escape of any hydrogen sul-

[1] Ber. deutsch. chem. Gesell., Vol. XXXII, p. 2217, footnote, 1899.

phide that may be formed—the sulphur of the sulphides becomes nearly, if not fully oxidized to sulphuric acid at the expense of the ferric iron in the rock, with the production of an equivalent amount of ferrous iron in addition to that resulting from the sulphide itself. Now, rocks with hardly an exception, and many minerals, carry pyrite or pyrrhotite, or both, often in considerable amount, often in traces only. My own experience has been that sulphur can almost always be detected in 2 grams of rock powder.

Let us now see what the effect of these traces when fully oxidized amounts to. One atom of sulphur (32) requires for its complete conversion to trioxide the oxygen of three molecules of ferric oxide (480), which then becomes six molecules of ferrous oxide (432). In other words, 0.01 per cent of sulphur may cause the ferrous oxide to appear too high by 0.135 per cent, and 0.10 per cent of sulphur may bring about an error of 1.35 per cent in ferrous oxide. The case is still worse if the sulphur is set free as hydrogen sulphide from a soluble sulphide, for then the above percentages of sulphur produce errors of 0.18 and 1.8 per cent, respectively, in the ferrous oxide determination.

The error caused by sulphides tends to become greater the more there is present of either or both sulphide and ferric salt. Now, the highly ferruginous rocks usually carry more ferric iron than the less ferruginous ones, and they are often relatively high in pyrite and pyrrhotite; hence the increasing discrepancy between the results by the two methods as the iron contents of the rocks rise is fully in accord with the above explanation.[1]

Notwithstanding that the Mitscherlich method has thus been discredited in its general applicability to rocks and minerals, it is still capable of affording valuable assistance with those which are totally free from sulphides. Hence the conditions under which success can best be achieved by it are set forth in the following paragraphs.

THE MODIFIED MITSCHERLICH METHOD.

Strength of acid.—The method in its original and usual application calls for a mixture of three parts of sulphuric acid and one of water by weight, or about three to two by volume, though a still stronger acid is sometimes used. In some cases, however, perhaps in most, much better decomposition of the silicates is effected by reversing the proportions of water and acid, or at any rate by diluting considerably beyond the above proportion. Hereby the separation of salts difficultly soluble in the stronger acid is avoided and the actual solvent effect on the minerals seems to be in no wise diminished.

[1] For details of experiments showing the worthlessness of the Mitscherlich method for rocks and minerals which contain even a trace of free sulphur or sulphides, see Hillebrand and Stokes, in an as yet unpublished paper in Jour. Am. Chem. Soc., Vol. XXII, and Zeitschr. für anorg. Chem., Vol. XXV, 1900, entitled, Relative value of the Mitscherlich and hydrofluoric-acid methods for ferrous iron determinations.

Filling, sealing, and heating of the tube.—The very finely powdered mineral having been introduced into a tube of resistant glass free from ferrous iron, the open end is drawn out, so as to leave a funnel for the introduction of the acid. A very little water is then introduced and carefully heated to boiling for a moment to expel all air from the powder. The diluted acid—which has just been boiled down from a state of greater dilution in order to have it free from air—is then poured in until the tube is about three-fourths filled. Carbon dioxide is then introduced from a generator which has been in active operation for some time, through a narrow glass tube drawn out of the same kind of glass as that of which the decomposing tube consists. In a few moments the air is expelled, and the small tube is then sealed into the large one over the blast lamp without interrupting the gas current until the very last instant, when to prolong it would perhaps cause a blowing out of the softened glass. The interruption of the current at the proper moment is easily effected by the pressure of the thumb and finger holding the small tube at the point where it enters the rubber tube leading from the gas generator. No breakage in the oven ever occurs as a consequence of thus fusing one tube into the other.

The heating is done in a bomb oven at any desired temperature up to, say, 200° C., and continued at intervals until examination by aid of a low-power lens shows that decomposition is complete or has progressed as far as can be hoped for. By inclosing the glass in an outer tube of strong steel, properly capped[1] and containing a little ether or benzine to equalize the pressure on both sides of the glass, the temperature can be elevated far beyond what is otherwise permissible, and the decomposition will then doubtless be more complete with refractory silicates.

Reason for introducing gas and sealing as above directed.—The usual practice in employing the above method has been to expel air before sealing by introducing a few crystals or lumps of an alkali carbonate or bicarbonate, the gas set free on their contact with the acid being supposed to effectively expel all air. That this is not accomplished the following series of comparative results long since published elsewhere[2] fully show. The material used was the oxide of uranium U_3O_8, requiring by theory 32.07 per cent of UO_2. Operating as just above described on from 0.3 to 0.5 gram, the results were

31.06, 31.07, 29.72, 29.33, 29.89, 30.69,

whereas after filling the tube with gas from a generator there was found

32.11, 31.90, 32.15, 32.12, 32.06, 32.17, 32.28,

the average error of the former series being 1.78 per cent. The percentage error would, of course, be reduced by increasing the weight

[1] Ullmann, Zeitschr. für angew. Chemie, 1893, p. 274; Zeit. für anal. Chemie, Vol. XXXIII, p. 582; 1894.

[2] Bull. U. S. Geol. Survey, No. 78, p. 50; Chemical News, Vol. LXIV, p. 232, 1891.

of mineral operated on. An average error equal to the above when employing 1 gram of ferrous minerals would make the percentage for FeO about 0.3 per cent too low. While the absolute error might be the same in all cases, the relative error would increase with minerals low in ferrous iron.

THE HYDROFLUORIC-ACID METHOD.

This method is the one which has been almost exclusively used since the earliest years of the Survey's existence.

The specially ground powder, in a capacious crucible, is placed, after stirring up with dilute sulphuric acid, on a small water bath of a single opening (fig. 13) and covered with a glass funnel, the stem of which has been cut off near the flare, resting in a depression of the specially made cover, into which water constantly drops from a tubulated bottle, thus securing a perfect water joint and serving to keep the bath full. Through a small metal pipe carbonic-acid gas flows into the bath above the surface of the water, and rising through orifices in the cover fills the funnel and crucible.[1] The lamp under the bath is lighted and hydrofluoric acid is poured into the crucible through a platinum funnel, which is left in place to serve as an occasional stirrer, for which a rod or wire may be substituted. After boiling commences the rapid gas current can be safely interrupted, to be restored when the lamp is extinguished after one-half to one or more hours. A full stream of cold water is then caused to flow from the tubulated bottle into the bath, the overflow from the outlet tube being caught in a receiver. As soon as cool the contents of the crucible are emptied into a platinum dish containing cold water, and titrated till the first permanent color appears, which usually will last for only a few seconds. Duplicate determinations are to be advised whenever possible, since even with the utmost care the results will occasionally differ more than is allowable.

In absence of a suitable water bath an ordinary one can be used covered with a beaker, through a hole in the bottom of which a strong current of carbon dioxide is introduced, or the crucible may be set in a sand bath and covered in the same way with a broken beaker (Doelter).

The cause of the rapid disappearance of the first pink blush when titrating in hydrofluoric-sulphuric solution appears to be the ready oxidizability of manganous fluoride by permanganate. The latter can be added by the cubic centimeter to solutions already containing manganous sulphate in presence of hydrofluoric acid without producing a more than passing pink blush. The solution, however, takes on in ever-increasing intensity the red-brown color characteristic of man-

[1] J. P. Cooke, Am. Jour. Sci., 2d series, Vol. XLIV, p. 347, 1867.

ganic salts.. The decolorization due to this cause is hence much more pronounced in the case of rocks high in ferrous iron than of those low in this constituent, because of the greater amount of manganous salt

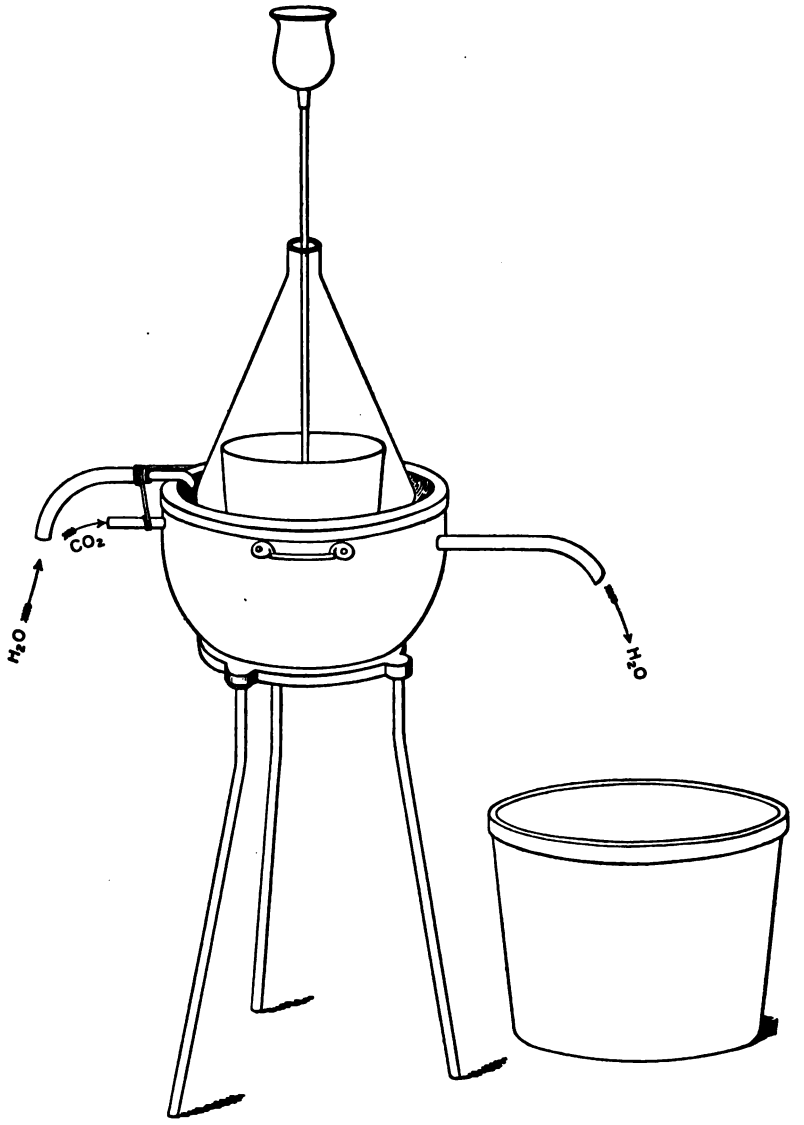

FIG. 13.—Cooke's apparatus for the determination of ferrous iron.

resulting from reduction of a correspondingly larger amount of permanganate.

When pyrite is present the bleaching is in part due to its action on any permanganate added in excess of the requirements of the ferrous

oxide. But this action is not so immediate as to affect the ferrous oxide determination if the end point in the latter has been properly observed.

PRATT'S MODIFICATION OF THE HYDROFLUORIC-ACID METHOD.

J. H. Pratt[1] has shown that very satisfactory ferrous iron determinations can be secured by simple boiling of the rock powder with hydrofluoric and sulphuric acids in a large crucible fitted with a cover and platinum tube for introduction of carbon dioxide. His test experiments on ferrous sulphate show that there need be practically no oxidation, even if the heating lasts several hours. The directions given on page 150 of his paper, with reference to the treatment of very refractory minerals which are not fully decomposed by this treatment, must be understood as referring only to homogeneous minerals and not to rocks, where the relations of ferrous and ferric iron in the undecomposed portion are certainly different from those in the part dissolved.

INFLUENCE OF SULPHIDES, VANADIUM, AND CARBONACEOUS MATTER ON THE DETERMINATION OF FERROUS IRON BY THE HYDROFLUORIC-ACID METHOD.

A dark color of the undissolved residue may be due to pyrite, graphite, or carbonaceous matter. The first of these affects the result but little, the second probably not at all, and they can be distinguished by their behavior toward nitric acid. Organic matter of course renders impossible the estimation of ferrous iron.

Sulphides.—Pyrite, in the quantities usually met with in igneous rocks, is probably without serious effect on the ferrous-iron determination by any of the hydrofluoric-acid methods. This sulphide is very resistant toward attack in the absence of oxygen, as is shown by the fact that if present in any quantity it can be readily recognized in the residue after titration. In any case it is impossible to allow for an error introduced by its possible decomposition, and the result of titration must count as ferrous iron. In the case of soluble sulphides two sources of error are introduced—that of reduction of ferric iron by hydrogen sulphide evolved, and that due to the ferrous iron which the sulphides themselves may contain, especially if pyrrhotite is present. The first of these is perhaps negligible, since most of the hydrogen sulphide would probably be expelled without reducing iron. The second is approximately measurable if it is known that pyrrhotite is the only soluble sulphide present, and its amount has been ascertained by determining the hydrogen sulphide set free on boiling with hydrochloric acid in a current of carbon dioxide. In this case a correction is to be

[1] Am. Jour. Sci., 3d series, Vol. XLVIII, p. 149, 1894.

applied to the result of titration for total ferrous iron. (See also p. 106, under Sulphur.)

In order to obtain quantitative data regarding the effect of pyrite on the ferrous-iron estimation by the hydrofluoric-acid method the following tests were recently made: Part of a fine crystal of pyrite was rather finely powdered and boiled with dilute sulphuric acid, which extracted considerable ferrous iron, derived presumably from admixed or intergrown pyrrhotite, since a second boiling with fresh acid gave a negative test for ferrous iron. After washing by decantation with water, followed by alcohol and ether, the powder was dried and further pulverized. A quarter of a gram of it when treated with hydrofluoric and sulphuric acids in a large crucible by the Cooke method for ferrous iron, then rapidly filtered through a very large perforated platinum cone fitted with filter paper, required but 2 drops of a permanganate solution representing only 0.0032 gram FeO to the cubic centimeter.

Since, however, Dr. H. N. Stokes has found in a pending investigation that the oxidizing effect of ferric salts on pyrite and other sulphides is vastly greater than seems to have been suspected (see p. 89), the following tests were made in order to ascertain the probable error due to this action under the conditions prevailing in rock analysis: Successive portions of 1 gram each of a hornblende-schist, free from sulphur and carrying 10.09 per cent FeO as the mean of several determinations and 4.00 per cent Fe_2O_3, were mixed in a large (50 cm.^{3}) platinum crucible with 0.02, 0.025, and 0.10 gram, respectively, of the above purified pyrite powder, and treated with hydrofluoric and sulphuric acids by the Cooke method, the water bath being at boiling heat for one hour. The cooled contents of the crucible were poured into a platinum dish containing water and titrated rapidly nearly to an end. Then, in order to get rid of the pyrite, which would obscure the end reaction by its reducing effect on the pemanganate, the solution was filtered as above and in the clear filtrate the titration was carried to completion. The results were 10.02, 10.16, and 10.70. Inasmuch as the smallest of these three charges of pyrite was several times greater than what may be considered an unusually high amount for an igneous rock, it is very evident that for all practical purposes the influence of pyrite on the ferrous estimation by the Cooke method is negligible. At the same time it is to be borne in mind that with increased content in ferric iron an increased amount of pyrite will be attacked, and that the extent of this attack is undoubtedly influenced by the degree of fineness of the pyrite powder.

Vanadium.—If vanadium, when present, exists in the trivalent condition, it necessarily affects with an error varying with its amount the result of titration for ferrous iron. Knowing the amount of vanadium a correction can be applied as follows: One molecule of V_2O_3 (150.8)

in oxidizing to V_2O_5 requires as much oxygen as four molecules of FeO (288) when oxidized to Fe_2O_3. The proportion, 150.8 : 288 :: V_2O_3 present : x, therefore gives the figure to be deducted from the uncorrected value for FeO. That this correction is very needful with many of the basic rocks becomes at once evident from the following perhaps extreme example:

Found 2.50 per cent apparent FeO in a rock containing .13 per cent V_2O_3.
Deduct .25 per cent FeO equivalent in its action on $KMnO_4$ to .13 V_2O_3.
Leaving 2.25 per cent FeO corrected.
Found 5.00 per cent apparent total iron as Fe_2O_3 in the same rock.
Deduct .14 per cent Fe_2O_3 corresponding to .13 per cent V_2O_3.
Leaving 4.86 per cent corrected total iron as Fe_2O_3.
Deduct 2.50 per cent Fe_2O_3 equivalent to 2.25 per cent FeO.
Leaving 2.36 per cent Fe_2O_3 in the rock.

Failure to correct for the vanadium in both cases would have made the figures for FeO and Fe_2O_3, respectively, 2.50 and 2.22 instead of 2.25 and 2.36 as shown above.

Carbonaceous matter.—As said before (p. 94), matter of organic origin other than graphitic carbon renders the results of the ferrous iron determination altogether unreliable.

UNCERTAINTIES OF THE FERROUS IRON DETERMINATION.

From the foregoing it is apparent that, despite the utmost care in practical manipulation, the exact estimation of ferrous iron in rocks is one fraught with extraordinary difficulties and uncertainties. Only in absence of decomposable sulphides, and when the amount and condition of vanadium are known, can the result be regarded as above suspicion.

XX. ALKALIES.

THE LAWRENCE SMITH METHOD.

The various methods for getting at the alkalies in insoluble silicates differ more in the mode of attack of the mineral powder and in the immediately subsequent treatment than in the final stages. With very few exceptions, since the early days of the Survey's existence, all alkali determinations have been made by the method of J. Lawrence Smith,[1] which is far more convenient than and fully as accurate as those in which decomposition is effected by hydrofluoric and sulphuric acids, or by bismuth, lead, or boric oxides. One of its chief advantages is the entire elimination of magnesia at the start.

Decomposition of the powder is effected by heating it with its own

[1] Am. Jour. Sci., 2d series, Vol. L, p. 269, 1871; Am. Chemist, Vol. I, 1871; Annalen Chem. und Pharm., Vol. CLIX, p. 82, 1871.

weight of ammonium chloride and eight times as much precipitated calcium carbonate.

The ammonium chloride used must be purified, preferably by sublimation, or made by neutralizing pure ammonia by pure hydrochloric acid, and the calcium carbonate is best obtained from pure calcite by solution and reprecipitation. However obtained, this last is rarely free from alkalies, which must be estimated once for all in a blank test in order to apply a correction. Eight grams of the carbonate will contain usually from 0.0012 to 0.0016 gram of alkali chlorides, almost entirely the sodium salt, but the amount has been brought down to half the above by very long washing. This correction may be admitted at once to be a defect of the method, but it is one easily applied with safety.

The ignition may be made in a covered crucible of ordinary shape and of about 20 to 30 cm.^{3} capacity, heated to dull redness for not more than two-fifths of its height, but the heat has to be kept so low in this case to avoid loss by volatilization that perfect decomposition is not always assured. Hence, to avoid waste of time in very fine grinding, the form of crucible with cap originally advocated by Smith is very much to be preferred, since it permits, when set at an angle through an opening in the side of a fire-clay cylinder, of the application of the full heat of two burners, and perfect decomposition invariably results without the need of extraordinary care in grinding. The crucible used in this laboratory (fig. 14) for one-half gram of rock powder and 4 grams calcium carbonate is 8 cm. long, 1.8 cm. wide at the mouth, and 1.5 at the bottom. For double the amounts or more the dimensions are 8 cm., 2.5 cm., and 2.2 cm. The weights are 25 and 40 grams.

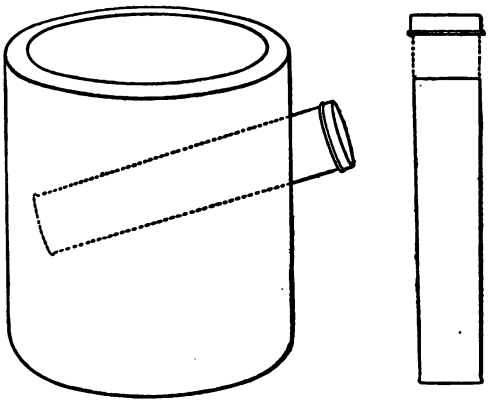

FIG. 14.—The J. Lawrence Smith crucible for alkali determinations. For dimensions see text.

Treatment of the mineral powder.—Perfectly satisfactory results are to be obtained with but a half gram of rock powder. This is weighed out, ground down somewhat finer in a large agate mortar, mixed with its own weight of sublimed ammonium chloride, and the two thoroughly ground together. Then nearly all of 4 grams of calcium carbonate is added and the grinding continued till a thorough mixing has resulted. The contents of the mortar are transferred to the long crucible, the rest of the carbonate being used for rinsing off mortar and pestle. The crucible is then capped and placed in a clay cylinder (fig. 14), or through

a hole in a piece of stout asbestos board clamped in a vertical position, and heated for about ten minutes by a low, flat flame placed at considerable distance beneath. As soon as the odor of ammonia is no longer perceptible the nearly full flame of two Bunsen burners is applied, and continued for forty to fifty minutes. The sintered cake[1] detaches readily from the crucible as a rule; if not, it is softened up in a few minutes by hot water and digested in a dish until thoroughly disintegrated. It is first washed by decantation, and any lumps are broken up by a pestle, then thrown on the filter and well washed with hot water. The residue should dissolve completely in hydrochloric acid without showing the least trace of unattacked mineral, not even of quartz.

Separation of calcium and sulphuric acid.—All but a trifling amount of the calcium is separated at boiling heat in a large platinum dish by double precipitation by ammonia and ammonium carbonate. The combined filtrates are evaporated to dryness and the ammonium salts are carefully driven off. From the aqueous solution of the residue—but a few cubic centimeters in bulk—the rest of the calcium is thrown out by ammonia and ammonium oxalate, this last being more effective than the carbonate. The filtrate, caught in an untared platinum crucible or small dish, is evaporated to dryness and gently ignited; the residue is moistened with hydrochloric acid to decompose any alkali carbonate that may have been formed, again evaporated, ignited, and weighed. On solution in water a few tenths of a milligram of fixed residue is invariably left, which should be collected, ignited, and weighed in the same crucible or dish in order to arrive at the weight of the chlorides.

If the rock contains sulphur this will be in part found with the chlorides as sulphate. Therefore, if the sulphur is at all considerable in amount it must be removed by a drop of barium chloride before the final precipitation of the calcium. The excess of barium is removed by ammonium carbonate and the last of the calcium by ammonium oxalate, as above. If the sulphur is not thus removed there is danger, if not certainty, of the potassium-platinic chloride carrying sodium sulphate. A faint reaction for sulphate can usually be obtained, anyway, if the evaporations have been made on a water bath heated by gas.

Precipitation of potassium.—To the solution of the chlorides in a small porcelain[2] dish an excess of platinic chloride solution is added. The dilution should be such that when heated on the water bath any precipitate that may form wholly redissolves. Evaporation is then carried on till the residue solidifies on cooling. It is then drenched

[1] To avoid the formation of a melted cake with silicates very high in iron it is advisable to increase the proportion of calcium carbonate.

[2] Preferred to platinum because of the possibility, under certain rare and ill-understood conditions, of the formation of an insoluble subchloride of platinum, probably by reaction between the platinum of the dish and that of the salt. (See also Bohn, Zeitschr. für anal. Chemie, Vol. XXXVIII, p. 349, 1899.)

with absolute alcohol[1] or with that of 80 per cent strength, filtered by decantation through a very small filter and washed by decantation with alcohol of the same strength. The precipitate is not brought onto the filter more than can be avoided. Dish and filter are then dried for a few minutes to remove adhering alcohol, the contents of the former are transferred to a weighed platinum crucible or very small dish, and what still adheres to the porcelain is washed through the filter with hot water into the weighed receptacle. This is now placed on the water bath and afterwards heated to 135° C. in an air bath. The factor used for reduction of K_2PtCl_6 to 2 KCl is 0.307 and of 2 KCl to K_2O, 0.632.

LITHIUM.

After separation of the potassium platinic chloride, the alcoholic filtrate is evaporated and tested spectroscopically for lithium. This element is almost invariably present, but almost never in amount to warrant quantitative estimation. Should it be so, however, the very excellent Gooch method (summarized below) of separation by amyl alchohol is to be followed, after removal of the platinum by hydrogen gas.[2] In rock analysis there need be no fear of enough lithium falling with the potassium to cause any concern.

If ammonium carbonate alone has been relied on to separate all calcium (ante, p. 98) the few tenths of a milligram of calcium chloride that escaped precipitation can now be found with the sodium.

GOOCH'S METHOD[3] FOR SEPARATING LITHIUM.

To the concentrated solution of the chlorides amyl alcohol is added and heat is applied, gently at first, to avoid danger of bumping, until, the water disappearing from solution and the point of ebullition rising and becoming constant for some minutes at a temperature which is approximately that at which the alcohol boils by itself, the chlorides of sodium and potassium are deposited and lithium chloride is dehydrated and taken into solution. At this stage in the operation the liquid is cooled and a drop or two of strong hydrochloric acid added to reconvert traces of lithium hydrate in the deposit, and the boiling continued until the alcohol is again free from water. If the amount of lithium chloride present is small, it will now be found in solution and the chlorides of sodium and potassium will be in the residue, excepting the traces for which correction will be made subsequently. If, however, the weight of lithium chloride present exceeds 10 or 20 milligrams, it is advisable at this point,

[1] Precht (Zeitschr. für anal. Chemie, Vol. XVIII, p. 513, 1879) claims that this is to be preferred to 80 per cent alcohol, especially if evaporation has been carried to dehydration of the sodium salt. Atterberg disputes this final statement and says that 80 per cent alcohol gives better results.

[2] When haste is not an object, this way of Bunsen's for removing platinum from the chlorides of the alkalies is by far the neatest and most satisfactory. The small flask containing the solution is placed in a water bath and attached to a hydrogen generator. After expelling all air the flask is closed, without breaking connection with the generator, and left to itself, except for occasional light shaking up, till reduction is accomplished. A more expeditious and very satisfactory reduction is effected by evaporating the solution to dryness with metallic mercury, then heating to expulsion of the excess of mercury and of its chloride (Sonstadt, Jour. Chem. Soc., LXVII, p. 984, 1895), who thus reduces potassium-platinic chloride in order to weigh its platinum.

[3] Proc. Am. Acad. Arts Sci., p. 177, 1886; Bull. U. S. Geol. Survey No. 42, p. 73, 1887; Chemical News, Vol. LV, pp. 18, 29, 40, 56, 78, 1887; Am. Chem. Jour., Vol. IX, p. 33, 1887.

though not absolutely essential to the attainment of fairly correct results, to decant the liquid from the residue, wash the latter a little with anhydrous amyl alcohol, dissolve in a few drops of water, and repeat the separation by boiling again in amyl alcohol. For washing, amyl alcohol, previously dehydrated by boiling, is to be used, and the filtrates are to be measured apart from the washings. In filtering it is best to make use of the perforated crucible and asbestos felt, and apply gentle pressure. The crucible and residue are ready for the balance after drying for a few minutes directly over a flame turned low. The weight of insoluble chlorides actually obtained in this manner is to be corrected by the addition of 0.00041 gram for every 10 cm.^{3} of amyl alcohol in the filtrate, exclusive of washings, if the insoluble salt is entirely sodium chloride, 0.00051 gram for every 10 cm.^{3} if potassium chloride constitutes the residue, and if both sodium and potassium chlorides are present, 0.00092 gram; but * * * the entire correction may in any case be kept within very narrow limits if due care be given to the reduction of the volume of residual alcohol before filtration. The filtrate and washings are evaporated to dryness, treated with sulphuric acid, the excess of the latter driven off, and the residue ignited to fusion and weighed. From the weight thus found the subtraction of 0.00050 gram is to be be made if sodium chloride constitutes the precipitate, 0.00059 gram if potassium chloride alone is present in the residue, and 0.00109 gram if both these chlorides are present, for every 10 cm.^{3} of filtrate, exclusive of washings.

Amyl alcohol is not costly, the manipulations of the process are easy, and the only objectionable feature—the development of the fumes of amyl alcohol—is one which is insignificant when good ventilation is available.

The process has been used for some months frequently and successfully, by others as well as by myself, for the estimation of lithium in waters and minerals.

SEPARATION OF ALKALIES BY OTHER METHODS.

When, as may happen in rare instances, it is necessary to estimate alkalies in the main portion after elimination of silica, alumina, lime, etc., in one of the usual ways, the question of a suitable method for separating magnesium becomes important.

The mercuric oxide method.—The old barium-hydroxide method is not to be recommended. The mercuric oxide method of Zimmermann, whereby the magnesia is precipitated from solution of the chlorides by moist, freshly precipitated, and alkali-free mercuric oxide, can give satisfactory results. The oxide is added in excess to the solution in a platinum crucible and evaporated to dryness. Then the mercuric chloride and most or all of the excess of oxide are expelled by cautious heating. On leaching with water the magnesia remains on the filter. With more than 1 per cent of magnesia the operation must be repeated (Dittrich).

The ammonium carbonate method.—Lately the once favored method of precipitating the magnesium by neutral ammonium carbonate in concentrated solution has been again recommended.[1] The magnesium solution must be as strongly concentrated as possible, and a great excess of ammonium carbonate solution must be used. A voluminous

[1] Wülfing: Ber. deutsch. chem. Gesell., Vol. XXXII, p. 2214, 1899. The neutral carbonate is prepared by dissolving 230 grams of ammonium carbonate in 180 cubic centimeters of ammonia of 0.92 *specific gravity* and enough water to make 1 liter.

precipitate forms, which dissolves on vigorous stirring if enough of the precipitant was used. After a time a crystalline precipitate falls—a double carbonate of magnesium and ammonium—which is insoluble in a concentrated solution of ammonium carbonate. Allow to stand for six to twenty-four hours. Wash with the concentrated ammonium carbonate solution. It is probably no exercise of undue caution to redissolve and reprecipitate, to make sure of getting all alkali in the filtrate.

The amyl alcohol method.—Under certain circumstances, notably absence of lithium, the method of Gooch developed by Riggs[1] may be satisfactory. It is similar to that of Gooch for separating lithium from sodium and potassium chlorides by amyl alcohol, and involves the same solubility corrections for the alkali chlorides above noted (p. 100) in the description of Gooch's method. Riggs's summary is as follows:

> Evaporate the solution nearly or quite to dryness. Dissolve the residue in as little water as possible and add a few drops of hydrochloric acid. Then add 30–40 cubic centimeters of amyl alcohol and expel the water by bringing the alcohol to boiling. Continue the boiling until the volume of the solution is reduced to 10 cubic centimeters, or even considerably less. In filtering, it is of great advantage to use a perforated crucible and an asbestos felt and to filter under pressure. In case the total chlorides exceed 0.2 grams it may be advisable to decant the liquid, wash the residue, redissolve, and repeat the precipitation. If this be not done, the precipitate should be redissolved with the least possible quantity of water, a few drops of hydrychloric acid added, and the precipitation repeated in the original solution. The filtrate is transferred to a weighed platinum dish and evaporated. Water is added before the alcohol has been expelled, and the evaporation continued. The residue is dissolved in water. Sulphuric acid is added in slight excess. This solution is evaporated to dryness, the residue ignited and weighed, and the treatment with sulphuric acid is repeated. The residue of insoluble chlorides may be transferred to the weighed perforated crucible and dried at a temperature below their melting points, or it may be dissolved and the solution transferred to a weighed platinum dish, evaporated, and the residue dried as above and weighed.

As with the Gooch method for lithium, the numerous test results are good.

XXI. CARBON DIOXIDE, CARBON.

For this estimation an apparatus (fig. 15) permanently set up is used, of which several forms have been described by different writers. The rock powder is boiled with dilute hydrochloric acid in a small Erlenmeyer flask, attached to an upward-inclined condenser, whence, after passing through a compact arrangement of drying tubes—first, one of calcium chloride, then one of anhydrous copper sulphate to retain hydrogen sulphide from decomposable sulphides and any hydrochloric acid that may pass over, and finally a second calcium chloride tube—the carbon dioxide is retained by absorption tubes filled with soda-lime followed

[1] Am. Jour. Sci., 3d series, Vol. XLIV, p. 103, 1892.

by calcium chloride. Of course arrangement is made for a current of CO_2-free air with which to sweep out the apparatus before and after the experiment, and for a slow current during its continuance. The

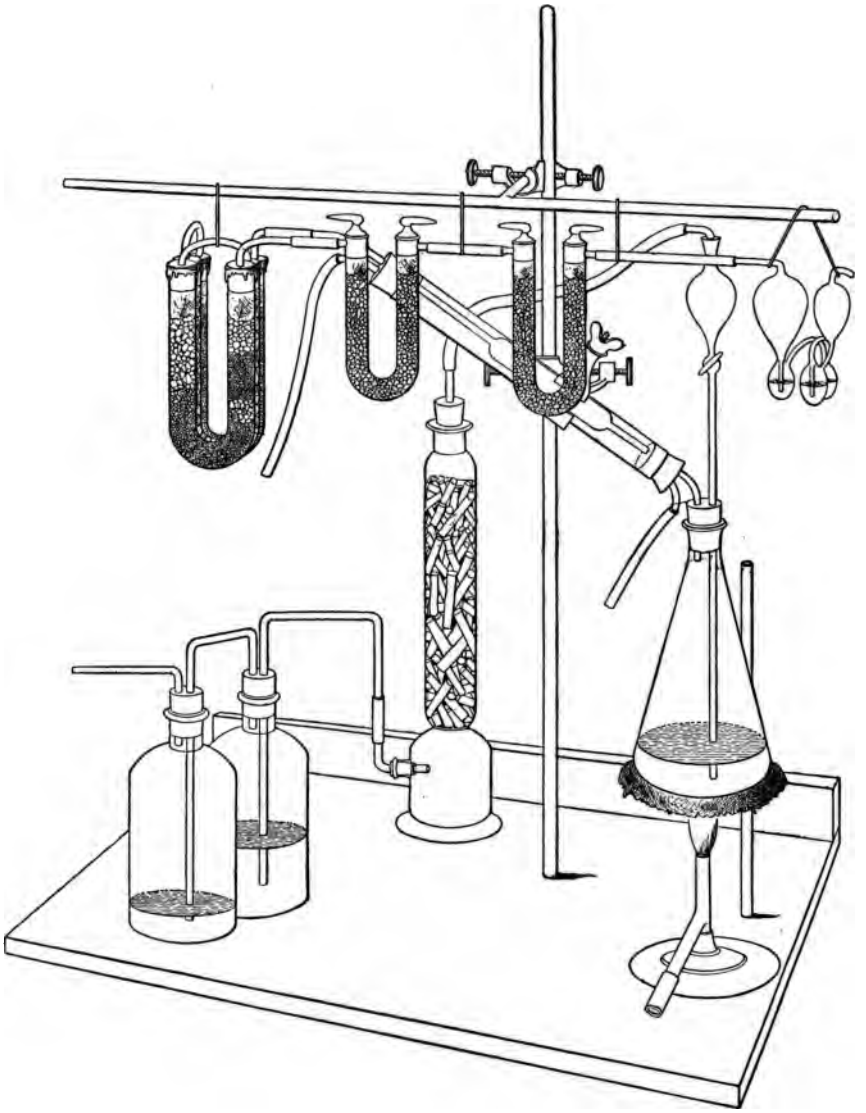

FIG. 15.—Compact form of apparatus for estimation of carbon dioxide.

results are very accurate and the determination can be quickly carried out.

In the preliminary qualitative test for carbon dioxide, it must be remembered that while calcite gives off its carbon dioxide on treatment with cold acid, dolomite and siderite do not, and hence warming

should not be omitted; otherwise, a few tenths per cent of carbon dioxide can very well be overlooked. Moreover, the powder should first be stirred up with a little hot water, to remove all entangled air which might otherwise be mistaken for carbon dioxide.

It has been already shown under Water (p. 45) how, in case of need, the determination of carbon dioxide can be combined with that of water by fusion with lead chromate or potassium chromate. This latter method must always be resorted to when the carbon of graphite or carbonaceous matter has to be estimated. If carbonates are present at the same time the result of the test includes the carbon from both sources, and a separate determination by the wet way of that of the carbonates is necessary.

XXII. CHLORINE.

To make sure of getting all the chlorine, it is best to fuse with chlorine-free sodium-potassium carbonate, or even sodium carbonate alone, first over the full burner, then for a moment or two over the blast, leach with water, acidify with nitric acid, and precipitate by silver nitrate without preliminary separation of silica. If 1 gram of material has been used no precipitation of silica need be feared on acidifying or on standing.

In many cases it is quite sufficient to attack the powder by chlorine-free hydrofluoric acid and a little nitric acid, with occasional stirring, and after filtering through paper fitted into a large platinum cone or rubber funnel, to throw down the chlorine by silver nitrate. The presence of nitric acid is necessary, since otherwise ferrous fluoride reduces silver nitrate with deposition of crystallized silver. When coagulated by heating and stirring, the precipitate is collected on the filter, washed, dissolved by a little ammonia, and reprecipitated by nitric acid, when it can be collected in a Gooch crucible and weighed, or, if very small in quantity, on a small paper filter, which is then dried, wound up in a tared platinum wire, and carefully ignited. The increased weight of the wire is due to the metallic silver of the chloride which has alloyed with it.

XXIII. FLUORINE.

Fluorine can only be estimated by the method of Rose, care being taken to use sodium-potassium carbonate as a flux, and to avoid use of the blast if possible. For minerals rich in fluorine and low in silica it may be necessary to add pure silica before the fusion in order to effect complete decomposition of the fluoride just as with the alkaline-earth phosphates. To the hot aqueous extract several grams of ammonium carbonate are added and more on cooling. After twelve

hours the solution is filtered, ammonium carbonate is expelled, and an ammoniacal solution of zinc oxide added, whereupon evaporation is carried on till the odor of ammonia is entirely gone. After filtering, add nitric acid in insufficient quantity to fully neutralize.

The use of ammonium nitrate or chloride, instead of carbonate, for throwing out the silica and alumina is not to be recommended, because of loss of fluorine on evaporation (Rose). If the rocks are very basic it may happen that the amount of silica in the alkaline solution is so small that ammonium carbonate may be dispensed with and the ammoniacal zinc oxide solution added at once.

By whatever modification of the method the silica and alumina may have been separated, the alkali carbonate must be converted into nitrate and not chloride if phosphorus or chromium, or both, are present. To remove the chromium and the last of the phosphorus, silver nitrate in excess is added to the solution containing still enough alkali carbonate to cause a copious precipitate of silver carbonate, which shall take up the acid set free and thus insure a neutral solution and consequent complete precipitation of phosphorus and chromium. After heating and filtering, the excess of silver is to be removed by sodium or potassium chloride, and sodium carbonate is to be added, in order to furnish by addition of calcium chloride in excess to the hot solution a sufficient admixture of calcium carbonate with the fluoride. At this stage there must be no ammoniacal salts in solution, otherwise calcium fluoride may be held up.

The next operation is perhaps best conducted as recommended by Penfield and Minor.[1] To the gently ignited precipitate of carbonate and fluoride of calcium at most 1–2 cm.^{3} of acetic acid are added in the crucible, which is then placed for a time on the water bath and afterwards its contents are evaporated to dryness. They are then taken up with hot water, the solution is decanted through a small filter, likewise the washings. The filter is burned in the same crucible, more acetic acid is added and the various operations are repeated until all calcium oxide and carbonate have been extracted. The above authors find that if a great excess of acetic acid is used at the start, the results are low. While their experiments related to the determination of fluorine in a mineral rich in that element—topaz—their precautions are probably not needless with the small amounts of fluorine met with in rocks.

The well-washed and gently ignited calcium fluoride finally obtained in the course of this method should be converted to sulphate as a check upon its purity, and at the same time as a qualitative test to ascertain if it really is calcium fluoride by the characteristic odor of the gas given off. Should fluorine be found, and the weight of sulphate not correspond to that of the fluoride, the former should be dissolved in

[1] Am. Jour. Sci., 3d series, Vol. XLVII, p. 389, 1894

hot nitric acid and tested for phosphorus by ammonium molybdate solution. If phosphate is absent the impurity may have been silica or calcium silicate—which of these it would be difficult to decide. In the former case the fluorine might be safely deduced from that of the sulphate, but not in the latter. If the rock were rich in sulphur it might happen that calcium sulphate would be thrown down with the fluoride, but this should be removed by thorough washing. If not, and it were certainly the only impurity present, the fluorine could be calculated, after conversion of the fluoride into sulphate, by the formula:

$CaSO_4 - CaF_2 : 2\ F : :$ Diff. between impure $CaSO_4$ and $CaF_2 : x$.

It is an exceptional case when there is exact agreement between the weight of fluoride and sulphate, and with the small amounts usually met in rocks the error may be an appreciable one in percentage of fluorine, though of no great significance otherwise.

There is no qualitative test which will reveal with certainty the presence of fluorine in rocks. Heating the powder before the blowpipe with sodium metaphosphate on a piece of curved platinum foil inserted into one end of a glass tube, or in a bulb tube, is not to be relied on in all cases. While as little as one-tenth of 1 per cent of fluorine can sometimes be thus detected with ease, much larger amounts in another class of rocks may fail to show.

XXIV. SULPHUR.

Before proceeding to the estimation of sulphur, its condition, if present, should be ascertained.

Evolution of hydrogen sulphide on boiling with hydrochloric acid is evidence of a soluble sulphide, usually pyrrhotite, but possibly lazurite. Extraction of magnetic particles reacting for sulphur shows pyrrhotite to have been in part at least the source of the hydrogen sulphide. A reaction for sulphuric acid in the filtered solution indicates a soluble sulphate, usually noselite or hauynite. If the residue, when well washed and treated with aqua regia or hydrochloric acid and bromine, gives more sulphuric acid, the probable presence of pyrite is shown. Should this solution likewise show arsenic, the sulphide may be arsenopyrite, which, however, is of very rare occurrence in igneous rocks, if, indeed, it is ever found there.

For the quantitative extraction of the sulphur of soluble sulphates, simple boiling with hydrochloric acid suffices, which should be done in an atmosphere of carbonic acid if pyrites or other oxidizable sulphides are present, and should be finished as quickly as possible in order to minimize the error resulting from oxidation to sulphuric acid of the sulphur of sulphides, if present, by any ferric salts that may have been dissolved.

The sulphur of sulphides may sometimes be correctly determined by extraction with aqua regia or some other powerful oxidizer, but not always; so that it is better by far to fuse with sulphur-free sodium carbonate and a little niter over the Bunsen burner, and for a few moments over the blast, fitting the crucible into a hole in asbestos board (Lunge) to prevent access of sulphur from the flame. After thorough disintegration of the fusion in water, to which a drop or two of alcohol has been added for the purpose of reducing manganese, the solution is filtered and the residue washed with a dilute solution of sodium carbonate. In the filtrate (100–250 cm.^{3} in bulk) the sulphur is precipitated at boiling heat by barium chloride in excess after slightly acidifying by hydrochloric acid. Evaporation to dryness first with acid, in order to eliminate silica, is needless, for in the above bulk of solution there will almost never be the least separation of silica with the barium sulphate. It is well that this is so, for evaporation on the water bath heated by gas to remove silica would in many cases involve an error fully equal to the sulphur present by contamination from the sulphur of the gas burned.

Owing to the small amount of sulphur in rocks, special purification of the barium sulphate obtained is hardly ever needful, especially as it has been precipitated in absence of iron. Should there be fear of a trace of silica being present, it can be removed by a drop of hydrofluoric and sulphuric acids before weighing the barium sulphate.

This, of course, gives the total sulphur in the rock. If soluble sulphates and sulphides as well as insoluble sulphates and sulphides are present together, the sulphur of the first is found in solution after extraction by hydrochloric acid in a carbon-dioxide atmosphere, and that of the decomposable sulphides by collecting the hydrogen sulphide evolved.[1] In the residue the sulphur of the insoluble sulphides can be estimated, or from the total sulphur found in another portion its amount can be calculated. The error involved in the above estimation of the sulphur of soluble sulphides, due to the possible reducing effect of hydrogen sulphide on ferric salts, is probably negligible. Most of the hydrogen sulphide would be expelled before any such action could take place and probably before the ferric salts were largely attacked, but of course the small proportion of sulphur set free as such from pyrrhotite would escape estimation and introduce further uncertainty. In general, it would be safe enough to assume the composition Fe_7S_8 for pyrrhotite. However carefully all these separate determinations may be carried out, the final figures for ferrous and ferric oxides can hardly be regarded as more than approximations when much sulphide is present. (See pp. 94–95.)

[1] With pyrrhotite a small fraction of its sulphur—one-eighth if the formula Fe_7S_8 is adopted—is liberated as free sulphur and not as hydrogen sulphide.

XXV. BORON.

To the best of the writer's belief, it has never been found necessary in this laboratory to estimate boron in a silicate rock. Should the determination be required, since most silico-borates are insoluble minerals, it would probably be necessary to fuse with sodium carbonate, extract with water, faintly acidify with nitric or acetic acid, expel the boron by distillation with methyl alcohol, and collect the boric ether in a suitable manner. For simple borates, artificial or native, this method,[1] first devised by Rosenbladt and Gooch independently, gives entire satisfaction when all needful precautions are carefully observed, but its application to boro-silicates yet needs investigation, in view of the as yet unexplained very discordant results obtained some years ago by J. E. Whitfield in this laboratory on the mineral warwickite, a boro-titanate of magnesium and iron.

It is also quite possible that the accurate estimation of but a few milligrams or even less of boric oxide by the use of a large excess of lime as a retainer would not be feasible. Fluorine would have to be first removed by calcium nitrate or acetate before freeing the boron.

XXVI. NITROGEN.

Nitrogen has been found in igneous rocks or the minerals occurring in them by several observers. Thus, H. Rose[2] says that pitchstone gives off ammoniacal water on heating; Silvestri[3] mentions a nitride of iron in lavas from Etna; Sandberger finds ammonium carbonate to be given off from certain rocks of Pribram; the writer has shown nitrogen to exist in uraninite; Ramsay and others have noted it in traces with or without helium, etc., in numerous minerals; and later Erdmann[4] found it to be given off as ammonia on treating various minerals of "ancient igneous rocks" with a caustic alkali. Luedeking also found ammonium sulphate in a barite from Missouri, the presence of which the writer was able to confirm.

It has been noted in this laboratory on three separate occasions, when series of ores, roofing slates, and eruptive rocks were analyzed, that

[1] Rosenbladt (Zeitschr. für anal. Chemie, Vol. XXVI, p. 21, 1887) used magnesia for binding the boron, while Gooch (Proc. Am. Acad. Arts and Sci., p. 167, 1886; Bull. U. S. Geol. Survey No. 42, p. 64; Chemical News, Vol. LV, p. 7, 1887) preferred lime, as more active and reliable. Gooch and Jones have later (Am. Journ. Sci., 4th series, Vol. VII, p. 34, 1899; Chemical News, Vol. LXXIX, pp. 99, 111, 1899) upheld the use of lime and proposed, as a convenient though perhaps not quite so perfect substitute, sodium tungstate containing an excess of tungstic oxide. In this article they likewise indicate the precautions now used to insure complete collection and retention of the boron.

For a useful modification in the way of collecting the boric ether in ammonia before bringing in contact with the lime, see Penfield and Sperry (Am. Journ. Sci., 3d series, Vol. XXXIV, p. 222, 1887); also Moissan (Comptes Rendues, Vol. CXVI, p. 1087, 1893, and Bull. Soc. Chim., Vol. XII, p. 955, 1894), who modifies the Gooch distilling apparatus in certain respects.

[2] Quantitative Analyse, p. 673. Finkener edition.

[3] Gazz. chim. ital., Vol. V, p. 303, 1875.

[4] Ber. Deutsch. chem. Gesell., Vol. XXIX, p. 1710, 1896.

ammonia, either in the form of chloride or sulphate, or even as free ammonia, was given off on heating. Its appearance was not limited to one or a few specimens of a series, but seemed to be characteristic of all, and to be afforded by the unbroken rock as well as by the powdered sample. The precise conditions under which the specimens were collected not being known, it is impossible to affirm positively that the ammonia may not have been due to recent organic contamination of some sort, especially in the case of the slates, but it is believed that a more critical collection of material will not alter the general result. Its amount was sometimes readily determinable by Nesslerization, being as high as 0.04 per cent in some slates. Carbonaceous organic matter was absent from most of these, but doubtless existed in them in their early history. In their case the ammonia was, in part at least, evolved as such, imparting a strong alkaline reaction to the water in the upper part of the tube. The presence of sulphides, fluorides, or chlorides in the rock might cause the ammonia to appear as a sublimate of sulphate, fluoride, or chloride. Speculation on this matter would be altogether premature, but attention is called to it in the hope that other observers may be led to look for and investigate similar appearances. It should be borne in mind that the nitrogen present would not necessarily appear as ammonia or ammonium salts, since it might be given off in the elemental condition, as with the gases obtained from uraninite.

XXVII. SPECIAL OPERATIONS.

The problem often presents itself of ascertaining the composition of that portion of a rock powder which is soluble in special reagents or in a reagent of a particular concentration. No precise directions can be formulated to meet such cases. The procedure must vary with the character of the constituents of the rock and with the object which it is sought to attain, and only in exceptional cases can a separation of this kind be sharp. Much depends on the degree of fineness of the powder and on the length of time it is exposed to the action of the reagent.

DETECTION OF NEPHELINE IN PRESENCE OF OLIVINE.

For confirmation of the microscopic diagnosis, Prof L. V. Pirsson[1] has indicated a means of detecting nepheline in presence of olivine, as in nepheline basalts, based on the very ready solubility of nepheline, as compared with olivine, when boiled for but one minute with a sufficiency of very dilute nitric acid (1:40). Gelatinization of the filtrate on evaporation is taken as evidence of the presence of nepheline. If olivine

[1] Am. Jour. Sci., 4th series, Vol. II, p. 142, 1896.

is present in quantity, however, this test must not be accepted at once as final, for some, if not all, olivines are much more soluble in nitric acid of the above strength than Professor Pirsson was led to believe from his original tests. If, therefore, on evaporation of the filtrate, much iron is indicated, the gelatinization may well be due to olivine alone or in part, and then the quantitative relation of silica to iron plus magnesium should be ascertained. It must also be borne in mind that any other very soluble silicates present will be more or less affected, and that apatite is largely or wholly dissolved. It is possible that still more dilute nitric, or perhaps some other, acid may exert a slighter solvent action on olivine without being appreciably less effective in dissolving nepheline, etc. In combination with a quantitative analysis of the extract the method is perhaps susceptible of a wider application than the particular case for which it was first used. It is well worth further study.

ESTIMATION OF SOLUBLE SILICA.

Very often in treatment by acids silica is separated in gelatinous or granular form mixed with the unattacked minerals, and it becomes necessary to remove or estimate this silica, or else to discriminate between soluble and insoluble silica already existing together. Usually a boiling solution of sodium carbonate has been employed for this purpose, though the caustic alkalies have found advocates.

Lunge & Millberg[1] have lately conclusively shown that quartz is not nearly so insoluble in solutions of the caustic alkalies as has been supposed, but that given a sufficient degree of subdivision it can be brought wholly into solution; that it is impossible to secure correct separation of quartz and opaline silica by the use of either caustic or carbonated alkalies; and that digestion on the water bath for 15 minutes with 5 per cent solution of sodium carbonate is the only way to secure exact separation of unignited precipitated silica from quartz, and then only when the finest flour has been removed by levigation. The authors say:

> If, however, no more of such flour is present than is produced in the ordinary operations of powdering and sifting through cloth of the finest mesh, the error arising from the above mentioned treatment is so slight that it can generally be neglected; it reaches 0.1 to at the most 0.2 per cent of the total silica, by which amount the quartz will appear too low, the amorphous silica too high.

The above authors also show, however, that the solvent action of the caustic alkalies on quartz becomes very apparent only when the material has been reduced to such an utterly impalpable degree of fineness as is practically never reached in the preparation of samples for rock analysis. For this reason I have no hesitation in recommending the employment of a dilute solution of sodium hydroxide when

[1] Zeitschr. für angewandte Chemie, 1897, pp. 393, 425.

the silica separated by acid from one of several mineral constituents of a rock is to be estimated. Even when dilution is considerable, solution is almost immediate, and as soon as this is accomplished—the point being known by the change in appearance of the residue—the solution should be diluted with cold water and filtered at once. The difficulty met with in filtration may often be overcome by faintly acidifying, which has the added advantage of at once arresting any further action of the alkali. If the dilution is sufficient no separation of silica results from so doing. Very dilute acid should also be used for washing. Lunge, when using sodium carbonate, washes with hot carbonate solution to which alcohol has been added, thus obtaining clear filtrates.

XXVIII. ESTIMATION OF MINUTE TRACES OF CERTAIN CONSTITUENTS.

If, as sometimes may happen, the problem is presented of examining rocks for traces of gold, silver, and other elements which are not ordinarily looked for, as in Sandberger's investigations bearing on the origin of the metalliferous contents of veins, large weights of material must be taken, up to 50 grams or more. This involves the use, also, of large quantities of reagents, the purity of which must then be looked to with the utmost care. Special directions to meet such cases can not now be given, nor even a complete reference list of the scanty and scattered literature on this subject. Sandberger's own writings deal but little with its analytical side, and from its inaccessibility in the Washington libraries the writer is as yet unacquainted with the report by Von Foullon "Ueber den Gang und die Ausführung der chemischen Untersuchung,"[1] following Sandberger's own paper in the general report "Untersuchungen der Nebengesteine der Pribramer Gänge."[2] The present writer has published a few data as to gold, silver, lead, zinc, etc.,[3] in Mr. S. F. Emmons's report on "The Geology and Mining Industry of Leadville;" and Mr. J. S. Curtis,[4] in his report on "The Silver-Lead Deposits of Eureka, Nevada," has given his method of assaying rocks for traces of gold and silver.

To Prof. F. W. Clarke and Dr. H. N. Stokes the writer's thanks are due for friendly suggestions in the preparation of the foregoing work.

[1] Jahrbuch der Bergakademie, Leoben u. Pribram, 1887, p. 363.

[2] From Sandberger's report it appears that the rocks were treated successively with water, acetic acid, boiling dilute hydrochloric acid for two days, and finally hydrofluoric acid, the several extracts and final residue of fluorides (and pyrite) being separately examined for heavy metals. The products of distillation were also examined. A striking fact observed in all cases was the complete insolubility of the pyrite, even after the severe treatment mentioned. This speaks strongly in favor of the correctness of ferrous iron estimations in silicates by the hydrofluoric and sulphuric acid method when pyrite is present unaccompanied by other sulphides. (See p. 95.)

[3] Mon. U. S. Geol. Survey, Vol. XII, Appendix B, pp. 592-596, 1886.

[4] Mon. U. S. Geol. Survey, Vol. VII, pp. 120-138, 1884.

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